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TRANSPORTATION CONTROLS TO REDUCE MOTOR VEHICLE EMISSIONS IN PITTSBURGH, PENNSYLVANIA

GCA Corporation
Bedford, Massachusetts

December 1972

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16. Abstracts

The document demonstrates the nature of the Air Quality problem attributed to motor vehicle operation, the magnitude of the problem and a strategy developed to neutralize these effects in order that National Ambient air quality standard may be attained and maintained.

17. Key Words and Document Analysis. 17a. Descriptors

Motor Vehicle emitted pollutants - air pollutants originating within a motor vehicle and released to the atmosphere.

National Ambient Air Quality Standards - Air Quality Standards promulgated by the Environmental Protection Agency and published as a Federal Regulation in the Federal Register.

17b. Identifiers/Open-Ended Terms

VMT - Vehicle Miles Traveled
Vehicle Mix - distribution of motor vehicle population by age group.
LDV - light duty vehicle - less than 6500 lbs.
HDV - heavy duty vehicle - greater than 6500 lbs.

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Prepared by

GCA Corporation
GCA Technology Division
Bedford, Massachusetts

Contract No. 68-02-0041

EPA Project Officer: Fred Winkler

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ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
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- 1b -

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Many members of local and state agencies supplied data and critical analysis to the study.

Alan M. Voorhees, Inc., acted as subcontractors to GCA Technology Division and supplied major input to the study, especially in the areas of traffic data, control strategies, and implementation obstacles.

COMMENT REGARDING THE RETROFIT PROGRAM (STRATEGY No. 4)

It has been called to our attention that a retrofit program using the catalytic converter implies the use of unleaded fuel. There is some doubt that cars of model years 1968-1970, perhaps 1968-1971, even, can operate satisfactorily on 91 octane gasoline. The data shown below* indicate that the exclusion of the 1968-1971 model years from the vehicle age group to be retrofitted under the recommended program would cause a loss of 4.6% of CO emission reduction, leaving a net reduction due to the retrofit program of 3.6%. In other words, this is the amount of reduction from retrofit applied to model years 1972-1974 only, based on the derived VAD for Allegheny County (see Table II-15), as of 31 December 1977. Since only about 2.4% reduction from retrofit is needed to meet the federal standard for CO by 31 December 1977, there would remain a "pad" of some 1.2% which would result in a maximum 8-hour average CO concentration of about 8.9 ppm, still 0.1 ppm to the good. The obstacles to the retrofit program are analogous to those for the I&M program, i.e., regressive burden on those least able to pay, etc.

*Allegheny County VAD:	Pre-1968	1968-1970	1968-1971	1968-1974	1975-1978
(as of 12/31/77)	4.1%	13.6%	22.5%	55.3%	40.6%

From Table 6 of the paper by Kircher and Armstrong, the average emission factor for the 1968-1971 cars is 37 gm/mi, while the factor for the 1972-1974 cars is 19 gm/mi. Thus, the weighted reduction realized from the retrofit program is 44% of the 8.2%, or 3.6%. This equates to the expected ambient concentration (maximum 8-hour average) of 8.88 ppm.

NOTE: In the discussion of total net reduction to be realized from the recommended transportation control program (Sections I and IV), there is a source of possible confusion in the method of numbering the various strategies, due to the fact that two different lists are shown in two different sequences. In order to avoid this needless complication, it is suggested that the strategies tagged as "#1" and "#2" in the computation in pages I-12 and IV-6&7 and in Table I-4 be renumbered #2 and #3 to agree with the priority sequence shown in Table I-7. Thus, Strategy #1 will always be Inspection and Maintenance (I&M), Strategy #2 will always be the street improvement program, Strategy #3 will always be the parking and mass transit improvements program, and Strategy #4 will be the retrofit program (as modified above).

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I. INTRODUCTION AND SUMMARY

A. BACKGROUND

States were required to submit implementation plans by January 30, 1972, that contained control strategies demonstrating how the national ambient air quality standards would be achieved by 1975. Many urban areas could not achieve the carbon monoxide and oxidant air quality standards by 1975 or even 1977 through the expected emission reductions from the 1975 exhaust systems control. Major difficulty was encountered by many states in the formulation of implementation plans that included transportation control strategies (including, for example, retrofit and inspection, gaseous fuel conversions, traffic flow improvements, increased mass transit usage, car pools, motor vehicle restraints, and work schedule changes.) Because of the complex implementation problems associated with transportation controls, states were granted until February 15, 1973, to study and to select a combination of transportation controls that demonstrated how the national air quality standards would be achieved and maintained by 1977.

B. PURPOSE, SCOPE AND LIMITATIONS OF STUDY

The purpose of the study reported on herein was to identify and develop transportation control strategies that will achieve the carbon monoxide and oxidant air quality standards required to be met by Pennsylvania in the Pittsburgh urban area by the year 1977. The results of the study were to help determine the initial direction that the Commonwealth of Pennsylvania should take in selecting feasible and effective transportation controls. It was anticipated that the control strategies outlined in this study would be periodically revised in the coming years. State implementation plans were analyzed to verify and assess the severity of the carbon monoxide and oxidant pollutant problems, and the most promising transportation controls and their likely air quality impact were determined. Major implementation obstacles were noted after discussions with those agencies responsible for implementing the controls and, finally, a surveillance review process (January 1973 - December, 1976, inclusive) was developed for EPA to use in monitoring implementation progress and air quality impact of transportation control strategies.

It should be noted that the study was carried out relying on the best data and techniques available during the period of the study and further, that a large number of assumptions were made as to the nature of future events. The 1977 air quality predictions were based on extant air quality data and on predicted stationary source emissions and predicted traffic patterns, and these predicted parameters themselves were based on anticipated emission control techniques, anticipated growth patterns, and the assumed outcome of unresolved legal and political decisions. (The opening of key major traffic facilities before 1977 was particularly sensitive to the outcome of legal and political decisions.) Further, the development, ranking and selection of transportation controls were based on extant and predicted economic, sociological, institutional and legal considerations. Finally, the surveillance process presented in this report, although showing key checkpoints towards implementation of the recommended controls, is in itself dependent upon the same assumed pattern of future events.

It should be emphasized therefore, that to the extent that the time-scale of the recommended program permits, the conclusions and recommendations of this report should not be construed as a program which must be rigidly followed until 1977, but rather it should be regarded first, as a delineation as to what appears at the present time to be a feasible course of action to attain air quality goals, and secondly, as a framework upon which an optimum on-going program can be built as new data and techniques become available, as legal and political decisions are made, and as the assumptions as to future events are, or are not, validated.

C. CONTENT OF REPORT

Section II of this report describes how the pollutant concentration levels which could be expected to occur in 1977 in the Pittsburgh area were predicted. These levels were determined by an adaptation of the proportional model using motor vehicle emissions from traffic patterns predicted for 1977 together with predicted non-vehicular emissions for 1977 obtained from state agencies. Comparison of these predicted 1977 air pollutant concentrations with the national air quality standards enabled the computation of the motor vehicle emissions which would result in the air quality standards being met, and therefore, to what extent, if any, reductions in the predicted 1977 motor vehicle emissions would be required. In order to determine the pollutant concentration(s) which was to serve as the basis for the proportional model, an intensive evaluation of all existing meteorological and air quality data was performed.

The final determination as to the concentration value used was made in close cooperation with representatives of local and state agencies and of EPA.

Section III describes how candidate control strategies were developed, evaluated and ranked having regard to technical, legal, institutional, sociological and economic criteria. An important feature of this task was the continuing interaction between, on one hand, the GCA study team, and on the other hand, representatives of local and state environmental planning and transportation agencies, concerned citizen's groups, and EPA representatives.

Section IV presents the rationale for selecting the optimum package of controls necessary to achieve the required reduction in motor vehicle emissions and also presents the confirmed effect on air quality.

Section V deals in detail with the obstacles to the implementation of the selected strategies. Since the obstacles to implementation were important criteria in the evaluation of the feasibility of candidate transportation controls, there is considerable discussion on such obstacles in earlier sections.

Section VI presents the surveillance review process which will enable EPA to monitor the implementation progress and air quality impact of the recommended strategies. A curve showing predicted air quality levels for the years 1973 to 1977 and beyond is presented, based on the implementation of the recommended transportation controls. This will provide a basic indication of the way in which air quality should improve as time passes and as controls are implemented. In addition, important checkpoints are provided delineating the salient actions which must be taken in order to implement the strategies such as the obtaining of the necessary financing and legislation. Further, important background assumptions, such as growth rate are identified, and methodologies supplied, to provide verification that these assumptions are in fact, validated during the course of the program.

It should be noted,however, that the surveillance process thus provided is of necessity based on the problem, and the concomitant transportation controls,as they are presently perceived. An equally important part of any surveillance process is the continuing reassessment of both the problem itself and the appropriateness of the required controls. As was discussed earlier in this Introduction, the present study employed a whole range of extant data and techniques, and also of assumptions about the course of future events. This data base should be continuously reviewed as new information becomes available. Thus, although the key background parameters are called out in the Surveillance Process, a thorough and continuing review of all the data, techniques,and assumptions contained in this report will be required to properly update the problem definition and appropriate control measures.

D. SUMMARY OF PROBLEM AND REQUIRED TRANSPORTATION CONTROLS

1. Summary and Review

As a result of our investigation of the Pittsburgh region, it was found that while the federal standards for both carbon monoxide (CO) and oxidants (O_x) are being exceeded at the present time, only the CO emissions will constitute a problem by 1977. This is because, although the FMVECP together with the planned controls on stationary sources will not, of themselves, quite achieve the reduction necessary to meet the oxidant standards by 1977 (Table I-2), the transportation control strategies which will be required to achieve the standard for CO by that time will also satisfy the requirement for reduction of hydrocarbon (HC) emissions sufficient to assure a "safe" level of O_x concentrations.

The specific expected emissions and concentrations are shown in Tables I-1 and I-2. The small differences noted between the data in the body of this report (see Tables II-18 and II-19) and the data shown here are due solely to the use of the vehicle age distribution for Allegheny County in lieu of the distribution for the entire SPRPC Region. Tables II-13, II-15 and II-21 show the differences and the resulting emissions due to these differences. The model years shown are as of 1971. The computer program VEHEMI2 automatically shifts the derived age distribution forward or backward in time, to be compatible with the particular calendar year being investigated.

Figure I-1 shows the expected air quality levels for CO, first with no strategies applied and using the SPRPC vehicle age distribution and that for Allegheny County, then showing the effects of the various strategies.

TABLE I-1

TOTAL VEHICULAR EMISSIONS IN KG/DAY AND EXPECTED MAXIMUM 8-HOUR AVERAGE CO CONCENTRATIONS

IN PPM FOR PITTSBURGH, ZONE 1

YEAR	NO STRATEGIES		CO CONC.*	WITH STRATEGIES 1 AND 2		WITH I & M		WITH RETROFIT		NON-VEH.	TOTAL EMISS.	NET CO CONC.
	CO	HC		CO	HC	CO	HC	CO	HC	CO	CO	
1970	29,530	4,775	----									
1971	28,541	4,325	----									
1972	27,111	3,820	21.3							2,200	29,311	21.3
1973	24,554	3,399	19.3							1,940	26,594	19.3
1974	22,343	3,012	17.5	22,119	2,988					1,680	23,799	17.3
1975	19,538	2,558	15.2	18,910	2,488					1,419	20,329	14.8
1976	15,992	2,059	12.7	15,028	1,947	14,352	1,842	13,764	1,766	1,419	15,183	11.0
1977	13,120	1,704	10.6	12,207	1,596	11,108	1,424	10,197	1,307	1,419	11,616	8.4
1978	10,698	1,443	8.8	9,965	1,352	9,068	1,206	8,324	1,107	1,469	9,793	7.1
1979	8,897	1,221	7.6	8,300	1,145	7,553	1,021	6,934	937	1,520	8,454	6.1
1980	7,199	1,034	6.4	6,730	971	6,124	866	5,622	795	1,573	7,195	5.2
1981	5,974	928	5.5	5,598	873	5,094	779	4,676	715	1,628	6,304	4.6
1982	5,278	856	5.1	4,957	806	4,511	719	4,141	660	1,685	5,826	4.2
1983	4,825	791	4.8	4,540	746	4,131	665	3,792	610	1,744	5,535	4.0
1984	4,447	774	4.5	4,192	730	3,815	651	3,502	598	1,805	5,307	3.9
1985	4,404	770	4.6	4,154	726	3,780	648	3,470	595	1,868	5,338	3.9
1986	4,309	759	4.5	4,067	717	3,701	640	3,398	588	1,933	5,331	3.9

* Includes non-vehicular emissions - see Column 11

NOTE: It was assumed that the reductions in HC emissions from strategies 1 and 2 shown for Zone 1 were just offset by corresponding increases spread over the rest of the County; i.e., the County-wide total HC emissions were not changed as a result of the application of these strategies. See Table I-2

TABLE I-2

TOTAL VEHICULAR HC EMISSIONS IN KG/DAY AND EXPECTED MAXIMUM 1-HOUR AVERAGE OXIDANT CONCENTRATIONS IN PPM FOR ALLEGHENY COUNTY

YEAR	WITHOUT STRATEGIES	TOTAL EMISSIONS	OX CONC.*	WITH I & M	WITH RETROFIT	NON-VEHICULAR EMISSIONS	TOTAL EMISSIONS	% RED. REQD**	NET OX CONC
1970	124,141								
1971	112,553								
1972	99,500	128,320	.165			28,820	128,320	55.0	.165
1973	88,603	114,454	.153			25,851	114,454	49.5	.153
1974	78,588	101,471	.140			22,883	101,471	43.1	.140
1975	66,803	86,718	.122			19,915	86,718	33.4	.122
1976	53,822	71,247	.101	50,915	48,828	17,425	66,253	12.8	.095
1977	44,593	59,529	.084	39,777	36,516	14,936	51,452	0.0	<.080
1978	37,793	53,252	<.080	33,712	30,947	15,459	46,406		↓
1979	31,995	47,995	↓	28,539	26,199	16,000	42,199		↓
1980	27,124	43,684	↓	24,195	22,211	16,560	38,771		↓
1981	24,381	41,521	↓	21,748	19,964	17,140	37,104		↓
1982	22,505	40,245	↓	20,075	18,429	17,740	36,169		↓
1983	20,817	39,178	↓	18,569	17,046	18,361	35,407		↓
1984	20,374	39,378	↓	18,173	16,683	19,004	35,687		↓
1985	20,282	39,951	↓	18,092	16,608	19,669	36,277		↓
1986	20,020	40,387	<.080	17,867	16,402	20,357	36,759	0.0	<.080

* Maximum observed 1-hour average O_3 concentration; includes non-vehicular emissions - see Column 7.
** % reduction in HC emissions required to reach "safe" rate of 57,744 kg/day (based on 55% red. from .165 O_x conc.)

NOTE 1: Strategies 1 and 2 were not applied, since it was assumed that the Zone 1 reductions in hydrocarbons due to those strategies would not be realized in the rest of the County; i.e., the total emissions would remain unchanged. (See Note, Table I-1).

NOTE 2: Oxidant concentrations were derived from the data in Table II-20, page , and by reading the curve in Appendix J, 40 CFR 51, "backwards," assuming a "safe" HC emissions rate of 57,744 kg/day from all sources.

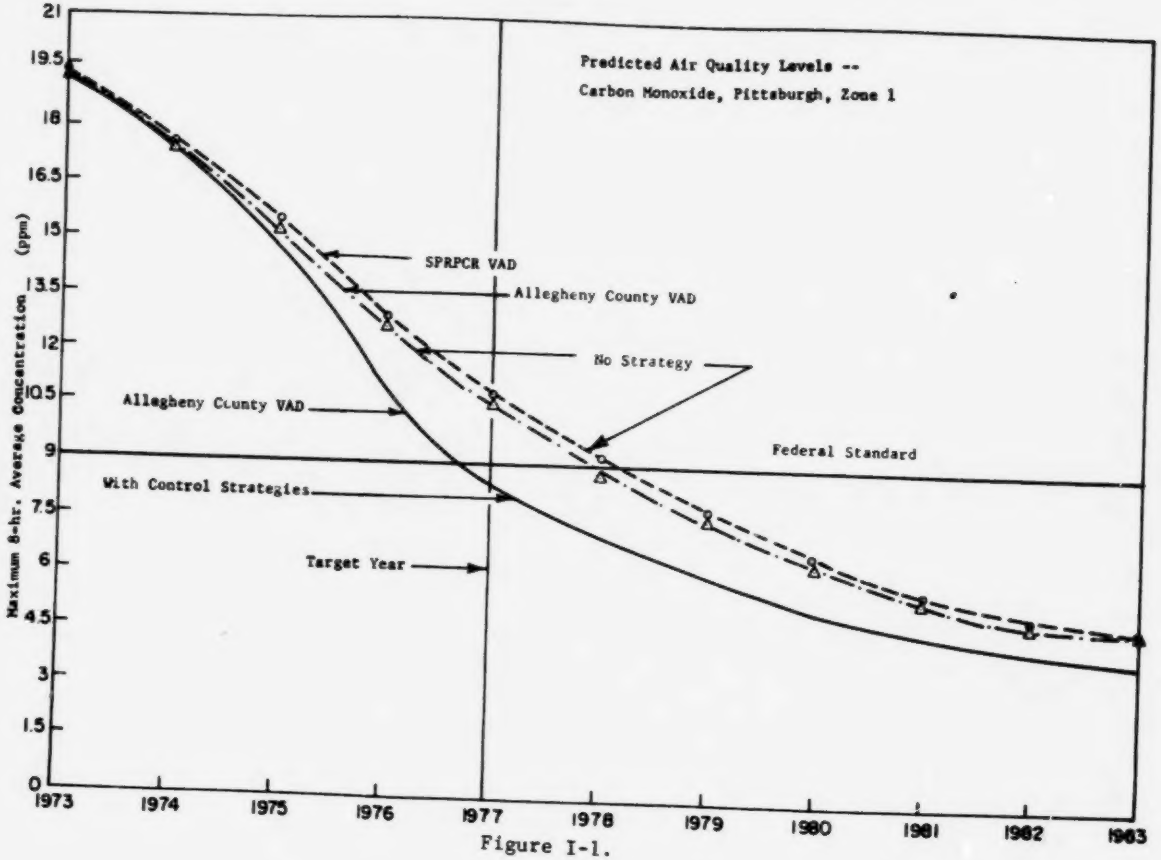
Predicted Air Quality Levels --
Carbon Monoxide, Pittsburgh, Zone 1
Maximum 8-hr. Average Concentration (ppm)
21
19.5
18
16.5
15
13.5
12
10.5
9
7.5
6
4.5
3
1.5
0
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
SPRPCR VAD
Allegheny County VAD
No Strategy
Allegheny County VAD
Federal Standard
With Control Strategies
Target Year

Figure I-1.

TABLE I-3

TOTAL VEHICULAR EMISSIONS, PITTSBURGH, ZONE 1 (Kg/day)

	WITHOUT STRATEGIES		WITH STRATEGIES 1 & 2	
CALENDAR YEAR	REGIONAL VEHICLE AGE DISTRIBUTION*		ALLEGHENY COUNTY VEHICLE AGE DIST.*	
	CO	HC	CO	HC
1970	29,845	4,852	29,530	4,775
1971	28,903	4,416	28,541	4,325
1972	27,543	3,923	27,111	3,820
1973	25,179	3,505	24,654	3,399
1974	22,916	3,113	22,119**	2,988**
1975	20,186	2,656	18,910**	2,488**
1976	16,705	2,154	15,208**	1,947**
1977	13,829	1,794	12,207**	1,596**
1978	11,340	1,523	9,965	1,352
1979	9,474	1,288	8,300	1,145
1980	7,658	1,084	6,730	971
1981	6,326	971	5,598	873
1982	5,551	890	4,957	806
1983	5,049	815	4,540	746
1984	4,593	793	4,192	730
1985	4,535	787	4,154	726
1986	4,401	771	4,067	717

* See Table II-13, p. II-58; and Table II-15, p. II-60.

** Transportation Control Program phased in over the 1974-1977 time period.

Because of the greater relative number of "new" cars in Allegheny County as compared with the rest of the Region (see Tables II-13 and II-15), the completed CO and HC emissions are somewhat lower if the local vehicle age distribution (VAD) is used. Because of the increasing influence on the total vehicle population of late-model "controlled" cars, this differential in computed emissions increases with time until about 1978, when the population begins to become more homogeneous (see Figure I-1). After that time, as the effect of uncontrolled vehicles becomes less important, the differences due to different VAD's become smaller again, ranging from 1% for 1970 up to around 5% for 1978 and 1979, then back down to 1% again by 1986.

While the effects of the individual strategies are broken out, year by year, in Tables I-1 and I-2, only the cumulative effect of the entire strategy package is shown in the bottom curve in Figure I-1.

2. Recommended Strategies

In order of preference, the recommended strategies are:

STRATEGY	AMOUNT OF ROLLBACK EXPECTED
Inspection and maintenance (affects entire Region)	9% (CO); 10.8% (HC)
Traffic flow improvements through the upgrading of existing streets (affects Zone 1 only)	1.4% (CO & HC)
Increase daily parking rate by $1.45, use existing parking space in fringe areas, and improve short-term mass transit (affects Zone 1 only)	5.5% (CO & HC)
Retrofit program (use of oxidizing catalytic converters) (affects entire Region)	8.2% (CO & HC)

The amounts of rollback shown are taken for each strategy as though it were the only one to be adopted. The actual amounts expected as a result of the total program package are shown below. The total net rollback is expected to be 22.2%[*]. The total rollback of vehicular emissions

---

[*] Computations of rollback percentages from various baseline values:

	REQUIRED	EXPECTED
From 1972 vehicular CO emission rate:	$\frac{27111-10965}{27111} = 59.6\%$	$\frac{27111-10213}{27111} = 62.3\%$
From 1972 total CO emission rate:	$\frac{29311-12384}{29311} = 57.7\%$	$\frac{29311-11632}{29311} = 60.3\%$
From 1977 vehicular CO emission rate:	$\frac{13120-10965}{13120} = 16.4\%$	$\frac{13120-10213}{13120} = 22.2\%$
From 1977 total CO emission rate:	$\frac{14539-12384}{14539} = 14.8\%$	$\frac{14539-11632}{14539} = 20.0\%$

required to meet the federal standard for CO by 1977 is 16.4% of the 1977 vehicular emission rate expected as a result of the FMVECP alone. The apparent "pad" of 5.8% in the recommended package of strategies is related to an air quality level of 8.4 ppm, only 0.6 ppm below the federal standard for CO (see Figure I-1 and Table I-1).

	Successive Reductions And Resultant Emissions Rates
1972 CO emissions from motor vehicles, Zone 1 (the "Baseline" value)	27,111 kg/day
Less expected reduction from FMVECP (51.6% of baseline)	13,991
1977 vehicular CO emission rate, no strategies	13,120
Less 1.4% emission reduction expected from traffic flow improvements (2% increase in average speed)	184 due to strategy 1 12,936
Less 5.5% emission reduction expected from parking strategies and improvements in short-term mass transit (5.5% decrease in VMT within Zone 1)	711 due to strategy 2 12,225*
Less 9.0% emission reduction expected from regional or state-wide inspection and maintenance program	1,100 due to I & M program 11,125*
Less 8.2% emission reduction expected from regional or state-wide retrofit program (oxidizing catalytic converters attached to 1968-1974 model year vehicles)	912 due to retrofit
Net expected CO emission rate for Zone 1	10,213* kg/day
Net expected rollback from 1977 "no-strategy" rate	22.2% (62.3% of 1972)

---

* The slight differences between these values and those shown in Table I-1 are due to the fact that the "with strategies 1 & 2" column in the Table uses the values generated by the computer programs VEHEMI2 and VEHEMI3, whereas the listing above only approximates the reduction in emissions from the 2% increase in average speed in Zone 1. In any event, the difference is very small: on the order of 0.15%.

From Table I-1 the e/c ratio is 29,311/21.3 = 1376.1; hence, the "safe" emission rate from all sources is 9 x 1376 = 12,384 kg/day. This is the rate to be attained by 1977;[*] assuming that the e/c ratio holds, it will just meet the federal standard of 9 ppm CO for the maximum 8-hour average concentration. Since the highest maximum value observed occurred in the CBD, and since the other zones are expected to have much lower emission rates (see Appendix C), the standards should be met by the recommended program everywhere within the Region. The expected CO emission rate from non-vehicular sources in 1977 is 1,419 kg/day. Adding this to the figure derived above for vehicular emissions gives an expected total emission rate of 11,632 kg/day. This is 6% below the so-called "safe" value of 12,384 kg/day, which requires a vehicular emission rate of 10,965 kg/day, and 20% below the no-strategy rate of 14,539 kg/day from all sources. The net vehicular CO emission rate derived above is 6.86% below this "safe" rate for vehicular emissions of CO; combined with the other emissions it would result in an ambient CO concentration of 11,632/1376 = 8.4 ppm, as shown in Table I-1.

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[*] In the absence of any prior direction on the effective date in 1977 by which these reductions were to be attained, and to maintain compatibility with the other data used in the computations (VMT, derived VAD, etc.), the computer program relates everything to 31 December of the calendar year. If it is desired to shift the effective date to some other day - say, 1 July - then the VAD may be used as given in Table II-13 but the VMT's will have to be altered by interpolation to account for the desired amount of temporal shift. Under these conditions, of course, since the FMVECP would be operating for a shorter time, the required emissions reduction from controls would be correspondingly higher.

TABLE I-4

PHASE-IN OF REDUCTIONS DUE TO EACH TRANSPORTATION CONTROL STRATEGY IN THE RECOMMENDED PROGRAM

	1974	1975	1976	1977
Strategy 1, Street Improvements	(27%)(2.0%)=0.54%	(70%)(2.0%)=1.40%	(93%)(2.0%)=1.86%	100%=2.0% incr. avg. speed
Values of SPD:	39.21, 19.10, 17.09 (27%)(1.4%)=0.38%	39.55, 19.27, 17.24 (70%)(1.4%)=0.98%	39.73, 19.35, 17.32 (93%)(1.4%)=1.30%	39.78, 19.38, 17.34 100%=1.4% decr. in emissions
Strategy 2, Parking & Transit Improvements	(10%)(5.5%)=0.55% (99.45%)VMT_{74}	(37%)(5.5%)=2.04% (97.96%)VMT_{75}	(83%)(5.5%)=4.57% (95.43%)VMT_{76}	100%=5.5% decr. in VMT (94.5%)VMT_{77}

See Table I-5 for values of VMT and SPD used in the "with strategies" runs.

After the computer run using the "strategy 1 & 2" values was made, the reductions for the other two strategies were computed by hand, assuming that 50% of the reductions due to the I & M and retrofit programs were effective in 1976 and 100% of these reductions were effective in 1977 and following years, as shown below:

Inspection and Maintenance			(50%)(9.0%)=4.5% (50%)(10.8%)=5.4%	100%=9.0% for CO 100% = 10.8% for HC
Retrofit, controlled vehicles only (1968 - 1974 model years)			(50%)(8.2%)=4.1%	100% = 8.2% for both CO & HC

The expected emissions resulting from the application of the above reductions in the manner shown are displayed in Tables I-1 and I-2.

TABLE I-5

VMT'S AND SPD'S FOR PITTSBURGH, ZONE 1, WITH STRATEGIES

		VEHICULAR MILES TRAVELED				OFF-PEAK SPEEDS, AVERAGE		
YEAR	CODE	LDV	HDV	OV	TOTAL	FREEWAY	ARTERIAL	LOCAL STREETS
1970	13	399,772	20,545	7,704	428,021	39.00	19.00	17.00
1971	14	407,054	20,919	7,845	435,818	39.00	19.00	17.00
1972	15	414,336	21,294	7,985	443,615	39.00	19.00	17.00
1973	16	421,619	21,668	8,125	451,412	39.00	19.00	17.00
1974	17	426,542	21,921	8,220	456,683	39.21	19.10	17.09
1975	18	427,287	21,959	8,234	457,480	39.55	19.27	17.24
1976	19	423,201	21,749	8,155	453,105	39.73	19.35	17.32
1977	20	425,958	21,891	8,209	456,058	39.78	19.38	17.34
1978	21	432,840	22,244	8,342	463,426	39.78	19.38	17.34
1979	22	439,721	22,598	8,475	470,794	39.78	19.38	17.34
1980	23	446,604	22,952	8,607	478,163	39.78	19.38	17.34
1981	24	453,487	23,306	8,739	485,532	39.78	19.38	17.34
1982	25	460,368	23,659	8,873	492,900	39.78	19.38	17.34
1983	26	467,251	24,012	9,005	500,268	39.78	19.38	17.34
1984	27	474,132	24,367	9,137	507,636	39.78	19.38	17.34
1985	28	481,014	24,720	9,271	515,005	39.78	19.38	17.34
1986	29	487,897	25,073	9,403	522,373	39.78	19.38	17.34
(1987)	30	(494,778)	(25,428)	(9,535)	(529,741)	FSPD = fraction of VMT's traveled at each speed class, Zone 1:		
(last line not used in computations)						0.17	0.13	0.70

The above values were the inputs to the programs VEHEMI2 and VEHEMI3 for the "with strategies" computer runs. They may be compared with the VMT's in the Appendices (see 1977 24-hour VMT for Zone 1), and with those listed in Table II-14, page II-80. The latter formed the basis for the "no-strategy" computer runs.

TABLE I-6

FRACTION OF TOTAL VEHICLES IN USE - LDV ONLY

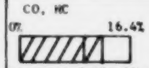
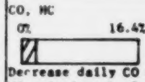
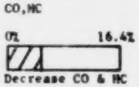
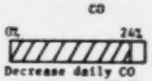
(As of 31 December)

AGE (YEARS)	NATION-WIDE	REGION-WIDE	COUNTY-WIDE
0	0.038	0.030	0.033
1	.068	.104	.114
2	.117	.124	.133
3	.111	.120	.126
4	.098	.111	.113
5	.106	.108	.108
6	.105	.110	.107
7	.087	.094	.089
8	.076	.071	.066
9	.059	.050	.045
10	.036	.028	.025
11	.029	.015	.013
12	.016	.009	.007
13+	.054	.026	.021

The above tabulation compares the nation-wide data as given in Table 14 of the paper by Kircher and Armstrong with those derived from the AMV data for the SPRPC Region and Allegheny County, respectively. The base year was 1971. The "zero years" age group refers to next year's models introduced in the fall; in this case, these would be the 1972 models. As explained in the text, the computer program shifts the selected VAD forward or backward in time from the year 1971, assuming that the same VAD holds for the calendar year being studied. The successively "younger" vehicle populations are evident as we go from the national average to the Regional distribution, then to that for Allegheny County by itself. The importance of this is that the greater the mix of "new" cars, the lower the overall rate of emissions from the given population. This is the reason for the apparent discrepancy between the numbers generated earlier in this study using the Regional figures, and those given here which are based on the County averages. Since it is good practice to use local distributions whenever possible, the lower emission figures are believed to be more nearly correct than those published in the Draft Report.

TABLE I-7

RECOMMENDED TRANSPORTATION CONTROL PROGRAM

Transportation Control Strategy	Emission Reduction	SOURCE OF EMISSION REDUCTION		Capital Costs	Non-Economic Impact
		Emission Rate Reduction	VMT Reduction		
#1 Inspection & Maintenance	 Decrease daily CO emissions by 9% and daily HC emissions by 10.8%	Expected to reduce HC emission rate by 10.8% and daily CO emission rate by 9.0%	No reduction expected	Approximately $38 Million	Program is adaptable to existing program. State legislation required.* Technology has been developed.
#2 Upgrading existing streets Traffic Flow Improvements	 Decrease daily CO and HC emissions by 1.4%	Due to 2 percent average daily speed increase, a 1.4% emission rate reduction	No reduction expected	Minimal capital cost	Similar program implemented. No legislative enactment needed. No technical innovation required.
#3 Increase daily parking rate $1.45, utilize existing parking spaces in fringe areas, and institute express bus service, extend coverage, decrease headways & increase running speed	 Decrease CO & HC emissions by 5.5 percent	No significant reduction expected	Expected to reduce VMT by 5.5%	Approximately $12 Million	Similar program implemented elsewhere. No legislative enactment needed. No significant technical innovation required.
#4 Retrofit	 Decrease CO & HC emissions by 8.2%	Expected to reduce daily CO & HC emission rates by 8.2%	No reduction expected	Approximately $34 Million**	Program is adaptable to existing program. State legislation required.* Technology has been developed.
Total Control Program	 Decrease daily CO emissions by 22.7%, HC emissions by 24 %. Desired reduction for CO is 16.4%.	An 18.5% HC emission rate reduction and a 16.7% CO emission rate reduction	A 5.5% VMT reduction	Approximately $84 Million	Program is implementable with State legislation.* No significant technical innovation required.

*Already in PL 154 (1972), Sections 834(a) and 850.

**Total capital cost of retrofit plus I&M is approximately $72 million for the SPRPC Region.

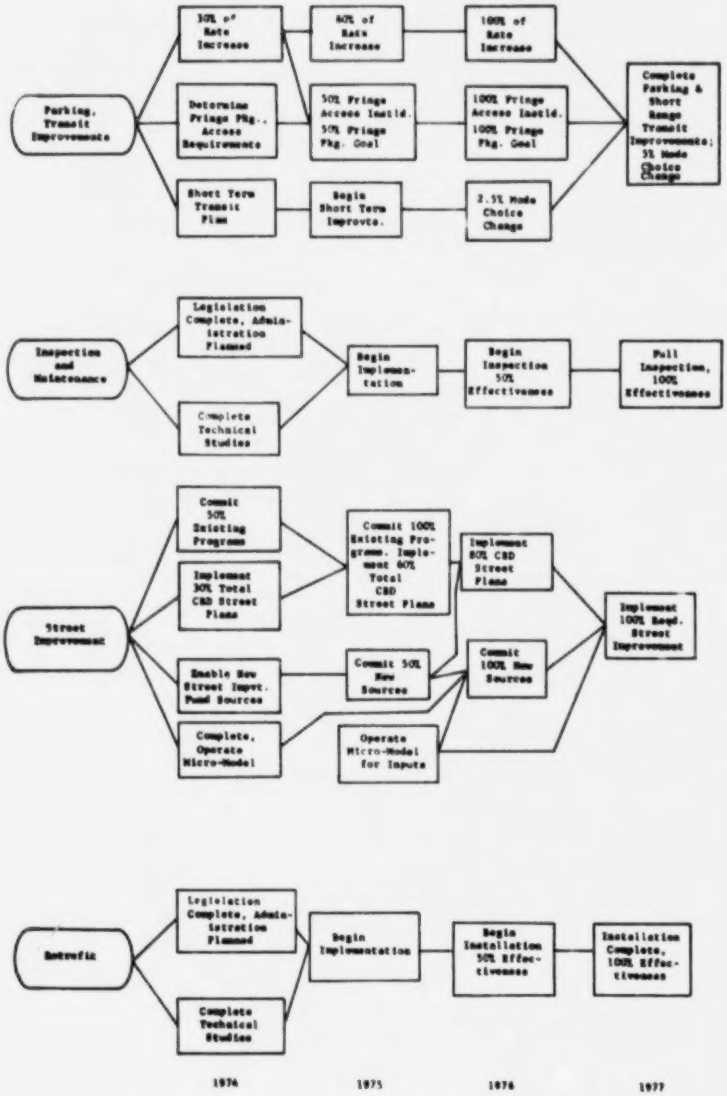

Parking, Transit Improvements
30% of Rate Increase
60% of Rate Increase
100% of Rate Increase
Determine Fringe Pkg., Access Requirements
50% Fringe Access Instld.
50% Fringe Pkg. Goal
100% Fringe Access Instld.
100% Fringe Pkg. Goal
Short Term Transit Plan
Begin Short Term Improvts.
2.5% Mode Choice Change
Complete Parking & Short Range Transit Improvements; 5% Mode Choice Change
Inspection and Maintenance
Legislation Complete, Administration Planned
Complete Technical Studies
Begin Implementation
Begin Inspection 50% Effectiveness
Full Inspection, 100% Effectiveness
Street Improvement
Commit 50% Existing Programs
Implement 30% Total CBD Street Plans
Commit 100% Existing Programs. Implement 60% Total CBD Street Plans
Implement 80% CBD Street Plans
Implement 100% Reqd. Street Improvement
Enable New Street Impvt. Fund Sources
Commit 50% New Sources
Commit 100% New Sources
Complete, Operate Micro-Model
Operate Micro-Model for Inputs
Retrofit
Legislation Complete, Administration Planned
Complete Technical Studies
Begin Implementation
Begin Installation 50% Effectiveness
Installation Complete, 100% Effectiveness
1974
1975
1976
1977

Figure I-2. Implementation schedule for the recommended transportation control program.

II. VERIFICATION AND ASSESSMENT OF AIR POLLUTION PROBLEM

A. OUTLINE OF METHODOLOGY

The basic procedure employed was to develop, for each city,[*] pollutant concentration levels which could be expected in 1977 without the application of transportation controls (the potential 1977 levels). Pollutant levels were determined by the proportional model using non-vehicular emissions supplied by state agencies and using vehicular emissions based on traffic data developed during the course of this study. More sophisticated techniques could not be employed due to the lack of suitable extant calibrated diffusion models, and the short time period of the contract which precluded the development of a suitable model and the required inputs. Comparison of potential 1977 air quality levels with the appropriate standard gave the allowable motor vehicle emissions in 1977, which in turn formed the basis for the development of transportation control strategies.

Emissions from non-vehicular sources were obtained from state implementation plans updated as required from information supplied by state agencies. Emissions from vehicular sources were computed following the recommendations given in EPA draft publication An Interim Report on Motor Vehicle Emission Estimation by David S. Kircher and Donald P. Armstrong, dated October 1972. Air quality data for each sensor within the city area was reviewed and evaluated in close cooperation with state and local agencies. The instrumental method and sensor location were studied and records of instrument maintenance and calibration examined so as to identify questionable readings. Meteorological records were then examined and compared with seasonal and diurnal variations in air quality levels. Finally the pollutant concentration which would form the basis for the proportional rollback calculations was decided upon in concert with state and local agencies and EPA representatives. The year in which this concentration level occurred defined the base year for the proportional rollback calculations.*

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[*] In this discussion, the word city is used to denote the urban area covered by the study and is not restricted to the area within the political limits of the city.

Because of the major differences involved, the detailed methodologies for carbon monoxide and oxidants are presented separately below.

1. Methodology for Carbon Monoxide

Because ambient concentrations of carbon monoxide at any given location appear to be highly dependent on carbon monoxide emissions in the near vicinity, it was felt that some justification existed for a modification of the proportional model. It was felt that in order to reduce ambient CO levels in, for example, a central business district (CBD), it would be more appropriate to roll back CO emissions in the CBD itself, rather than the entire air quality region. The assumption was therefore made that pollutant concentration in any given zone was directly proportional to the emission rate of that pollutant emission within that zone. Accordingly, each city area was divided into traffic zones - about the size of the central business district (CBD) in the center of the city with increasingly larger zones towards the suburban areas. Where traffic data was already available for existing "traffic districts" the traffic zones were either the traffic districts themselves or suitable aggregations thereof. Otherwise the traffic zones were based on rectangular grids.

---

*Because the air quality data for Pittsburgh were available for the period June 1971, to July 1972, and because the "as of" date of the VMT is December 1971, the fact that the highest 8-hourly maximum occurred in November 1971 makes all data closely compatible in time.

An emission concentration ratio (e/c ratio) was assigned to each sensor, the e/c ratio being based on the daily CO emissions (expressed in kg/24 hrs.) for the base year within the zone in which the sensor was located, and the CO concentration value which formed the basis of the proportional rollback computations. Based on the e/c ratios so obtained, the maximum allowable emission rate was derived which corresponded to the national air quality level to be achieved (i.e., 9 ppm for an 8-hour average). The emission rates for the critical zone were then prepared for years 1977, etc., based on the predicted vehicular and non-vehicular emissions for those years. Vehicular emissions were based on traffic patterns predicted for those years in the absence of any transportation controls imposed in order to meet national air quality standards for CO (the "no strategy case"). Non-vehicular emissions for the years of interest were obtained from state implementation plans and state agencies, and take into account predicted growth and the predicted control strategies to be applied to those sources. The predicted control strategies were generally those which state agencies considered to be the maximum feasible, and therefore the predicted non-vehicular emissions were assumed to be irreducible for the purposes of this study.

On the assumption that the predicted emission densities from non-vehicular sources were to be taken as irreducible, the allowable emissions from motor vehicles in each zone for the year of interest were then determined. For the purposes of evaluating the effects of candidate transportation controls, the maximum allowable emission rate for the year 1977 was expressed as a percentage reduction from the 1977 "no strategy" emission rate. However, as will be seen in following sections of this report, as each traffic control was developed, emissions were recomputed, using the revised VMT's and speeds resulting from the application of the control measures.

A typical summary sheet of the output of this methodology is shown in Table II-A. It should be noted that the term "without strategy" refers to a transportation strategy, i.e, one which affects only vehicle emissions. The non-vehicular emissions used reflected both the growth expected in such emissions and also the effect of various control strategies for non-vehicular sources as predicted by state agencies. It should also be noted that total emissions rather than emission densities are presented in Table II-A, since the summary refers to the rollback in one zone only.

TABLE II-A

SUMMARY SHEET FOR: PITTSBURGH

DATE: 5 January 1973

II. CARBON MONOXIDE

A. Zone for which emissions computed

Zone 1 - the Golden Triangle (downtown Pittsburgh)

B. Area: 1.26 sq. miles

C. Carbon Monoxide Emissions (kg/24 hr.) and CO levels (ppm)

	Present 1972	1975 Without Strategy	1977 Without Strategy	1977 with Oxidant Strategy Only	1977 with CO Strategy Only
Vehicular Emissions	27,111	19,538	13,120	13,120*	10,197
Non-Vehicular Emissions	2,200	1,419	1,419	1,419	1,419
Total Emissions	29,311	20,957	14,539	14,539	11,616
CO level (8-hr average)	21.3	15.2	10.6	10.6	8.4**

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*No special oxidant strategy planned

**Federal standard is 9.0 ppm

WITHOUT STRATEGIES

	1978	1979	1980	1982
Vehicular Emissions	10,698	8,897	7,199	5,278
Non-Vehicular Emissions	1,469	1,520	1,573	1,685
Total Emissions	12,167	10,417	8,772	6,963
CO level (8-hr average)	8.8	7.6	6.4	5.1

2. Discussion of Methodology for Carbon Monoxide

a. Modified Proportional Model Applications

Modified proportional model applications and the limitations of the conventional proportional rollback method have been well documented and reviewed[1] and need not be discussed further here. The technique used in the present study was an extension of the conventional rollback technique to the extent that it was assumed first, that the constant of proportionality between emissions and concentration may be derived from emissions emanating from the relatively small area around the sensor (the traffic zone), and second, that this constant of proportionality (the emission/concentration ratio) could be applied to determine pollutant concentrations in other zones of comparable area on the basis of the pollutant emissions in those zones.

Some justification of the first assumption can be found, for example, in recent work of Hanna[2] and Gifford[3] who demonstrate the dominance of urban pollution patterns by the distribution of the local area sources. The success of their urban diffusion model, in which concentration is simply directly proportional to the area source strength and inversely proportional to wind speed, is attributed largely to the relatively uniform distribution of emission within an urban area and the rate at which the effect of an area source upon a given receptor decreases with distance. In the proportional model, meteorological effects, such as wind speed, are assumed to be duplicated over one-year periods. The validity of the second assumption depends, in large part, upon the extent to which diffusion and transport parameters are uniform from zone to zone - a factor which could not be investigated because of the constraints of the program. Thus, it was felt that, in the absence of a more sophisticated technique, the use of this extension to the proportional model was justified first, to obtain some assessment as to whether the existing sensors were located in the hot-spots, and second, to obtain some assurance that transportation strategies intended to reduce emission densities in one zone (to the level required to meet ambient standards) did not increase emission densities to unacceptable levels in adjacent zones. In Pittsburgh it was found that the sensors were, in fact, in the "hot spot" zone and also that the recommended transportation controls did not increase emissions in adjacent areas to unacceptable levels. Thus the final rollbacks were confined to the zone with a sensor within its boundaries and the extensions of the techniques to other non-sensor zones did not, therefore, play a primary role in the final computations.

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[1] Noel de Nevers. Rollback Modeling, Basic and Modified. Draft Document, EPA, Durham, N.C. (August 1972).

[2] Hanna, S.R., "A Simple Method of Calculating Dispersion from Urban Area Sources," J. APCA 21, 774-777 (December 1971)

[3] Gifford, F.A., "Applications of a Simple Urban Pollution Model," (paper presented at the Conference on Urban Environment and Second Conference on Biometeorology of the Amer. Meteor. Soc., October 31 - November 2, 1972, Philadelphia, Pa.).

As might be expected, where an urban area had several sensors, the emission concentration ratios were widely different and this served to underline the fundamental limitations of the technique employed. An implicit assumption in the technique employed was that the air quality in a traffic zone could be fairly represented by one con -

centration level and that this level depended only upon the average emission density within that zone. The two major factors mitigating against this assumption are

(a) Emission densities are not uniform across even a small traffic zone.

(b) Concentration levels are not uniform across the traffic zone partly because of the lack of uniformity of emission density and partly because the point surface concentrations are affected by micrometeorology and microtopography as well as emission density.

Considerable judgment had to be used, therefore, both in the derivation of e/c ratios and in their subsequent use. In heavily trafficked downtown areas the variation was judged not to be too great, so that the single recorded concentration might reasonably be expected to be representative of the zone's air quality and emission density. However, in suburban zones having overall low traffic densities, sensors were often found to be placed at very localized hot spots, such as a traffic circle, so that the recorded concentration levels were neither representative of the overall air quality nor of the overall emission density in the zone.

Accordingly, e/c ratios were generally derived from sensors in the central areas of the cities and applied to suburban areas for the prediction of 1977 concentration levels. This procedure gave air levels which were generally representative of the suburban zone. However, it must be realized that control strategies based on this procedure, while they may ensure that the overall air quality in a suburban zone will not exceed ambient standards, do not preclude the occurrence of higher concentrations in very localized hot spots such as might occur in the immediate vicinity of a major traffic intersection.

b. Seasonal and Diurnal Variations

The carbon monoxide concentration level chosen as the basis for the base year e/c ratio in the CBD was the highest valid 8-hour average observed during the base year 1971-1972. The one-hour averages were very much closer to the standard than the 8-hour average, so that controls required to meet the 8-hour standard would also result in the 1-hour standard being met. Although seasonal variations in readings were noted, traffic data were not available on a seasonal basis, so that vehicle emissions were based on annual average work day traffic data.

c. Background Concentrations

Background concentration levels of CO were not taken into account. Where a zone was located near a large point source, simple "worst case" diffusion calculations were performed to assess the effect of the point source on the zone. In all cases, it was found that this contribution was negligible.

3. Methodology and Discussion for Oxidants

The technique employed for oxidants was basically the same as has just been described for CO with the major difference that only one, very much larger area, was used as the basis for the proportional rollback. Because of the length of time required for the formation of oxidants from hydrocarbon emissions, the relatively small areas used as the basis for CO could not be justified. The actual area used in each city was largely a matter of judgment and the decision was made in concert with state and local officials and EPA. In general, it was about the size of the metropolitan area. For Pittsburgh, Allegheny County was used.

The reductions in hydrocarbon emissions necessary to achieve oxidant ambient standards were obtained from Appendix J, Federal Register of August 14, 1971.

B. DISCUSSION OF 1971-1972 AIR QUALITY LEVELS

1. Natural Features

a. Topography

The Southwest Pennsylvania Intrastate Air Quality Control Region is designated in paragraph 81.23 of 40 CFR 81, Federal Register, Vol. 36, No. 228, 25 November 1971 in accordance with the provisions of the Federal Clean Air Act, as amended (42 USC 1857 as amended by PL 91-604) to consist of Allegheny County (Pittsburgh) and surrounding Armstrong, Beaver, Butler, Fayette, Greene, Indiana, Washington, and Westmoreland Counties (see Figure II-1). Most of the population and activity is concentrated in the City of Pittsburgh and suburban Allegheny County. The region lies to the west of the Allegheny Mountains of central Pennslyvania and occupies the central portion of the Allegheny Plateau, which extends from southwestern West Virginia through western and northern Pennsylvania into central New York. Several large rivers have cut deep valleys into the plateau, so that the terrain is characterized by quite rugged relief. The larger valleys, such as those of the Ohio, Allegheny, Monongahela and Youghiogheny Rivers, have steep sides and narrow, winding channels lying some 300 to 500 feet below the level of the plateau. Historically, commerce and industry developed along the river valleys, and the consequences in terms of air pollution have been apparent for generations. The City of Pittsburgh was founded at the point where the Allegheny and Monongahela Rivers join to form the Ohio River; today, the "Point" of the "Golden Triangle" is at the center of a large metropolitan region containing a major portion of the steel industry of the United States as well as much other industrial and commer-

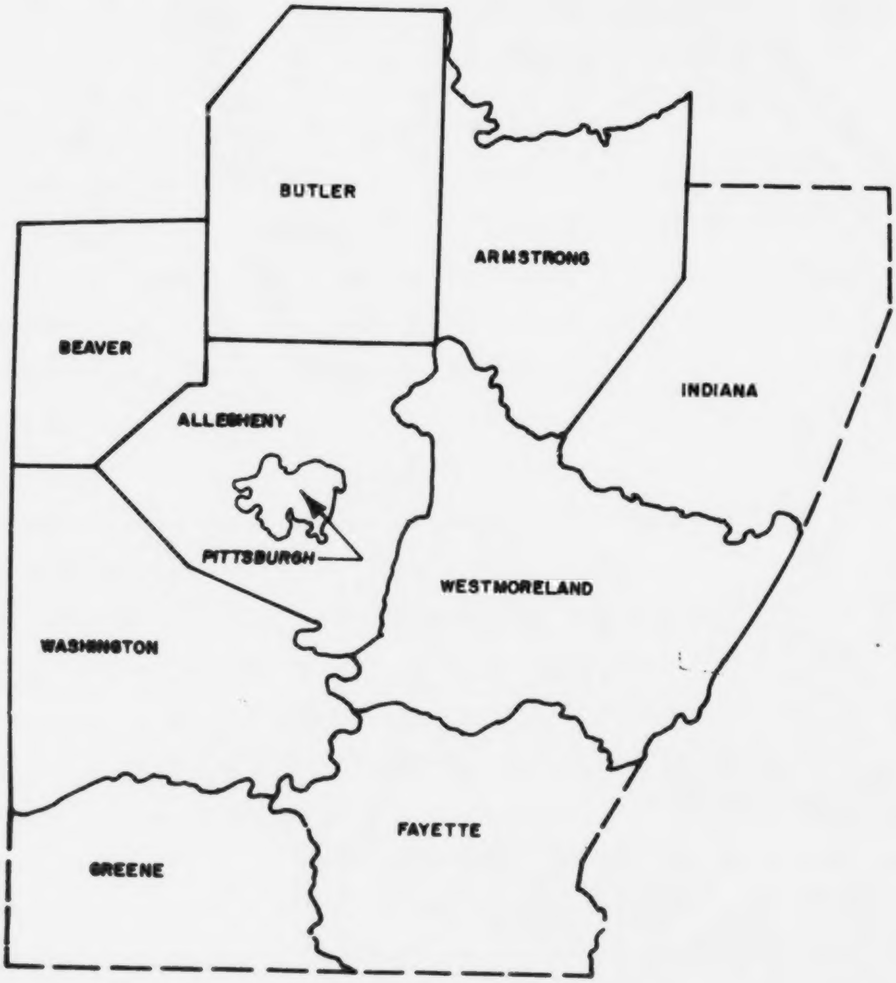

Figure II-1. SPRPC and SPAQC regions.

cial activity. The emanations from the many mills and factories are to a considerable extent trapped by the walls of the valleys and thus are not dispersed as they would be in more open terrain. This condition is exacerbated under conditions of atmospheric stability and especially when temperature inversions are experienced,as discussed in the following section.

b. Meteorology and Climatology

The Allegheny Plateau, shielded to a large extent from the moderating influence of the Atlantic Ocean by the Appalachian Mountains, is for the most part under the influence of continental polar air masses traveling from Canada by way of the Great Lakes or the Great Plains, although during the summer months the area is frequently overrun by maritime tropical air from the Gulf of Mexico. The Pittsburgh area, lying near the mean storm track for much of the year, is subject to moderately high annual amounts of precipitation and cloudiness, although episodes of slowly moving anticyclonic circulations, the so-called "stagnant highs", are fairly common, especially in the fall and winter months. Under these conditions the air becomes very stable, especially at night under clear skies when radiational cooling gives rise to pronounced temperature inversions near the ground. The pollutants from the numerous steel mills and other stationary sources, as well as those from motor vehicles, tend to become trapped in the lower layers of the atmospheric during the late night and early morning hours, until the increasing input of solar energy after sunrise can burn off the ground fog and clear the air generally by wiping out the inversion and restoring a more normal temperature distribution aloft. While this condition is certainly not unique to the Pittsburgh area, it is made worse there by the presence of concentrated emissions of pollutants in the narrow, deep, and winding valleys which act both as physical deterrents to the dispersal of pollutants and as delaying agents to the onset of the solar heating effect referred to above. There is an additional effect as well, that of the well-known "mountain and valley breeze", which tends to concentrate the colder air near the bottoms of the valleys during the hours of darkness, thus increasing still further the strength of the temperature inversions which are present on a regional basis anyway, and causing a further delay in their break-up during the day. All of this gives rise to frequent river fogs and, where concentrations of pollutants are present, to potentially severe air pollution episodes. One of the best-known of such occurrences, that at Donora, Pennsylvania, took place in 1948 not more than 20 miles from downtown Pittsburgh under precisely the conditions outlined above: stable atmosphere with little or no wind, cold weather, night-time hours, concentrated industrial emissions in a narrow, winding, steep-walled valley (that of the Monongahela River).

Next to terrain and atmospheric stability effects, the most important meteorological parameters for air pollution considerations are the wind speed and direction. These three factors, topography, stability, and wind velocity, are closely interrelated in many ways, but for our purposes it suffices to emphasize that, while the Pittsburgh area lies in the heart of the prevailing westerlies of the Temperate Zone (see Table II-1), the rough terrain creates wide variations from the mean wind velocity. In

TABLE II-1

PERCENTAGE FREQUENCY OF SURFACE WIND DIRECTION AND SPEED (FROM HOURLY OBSERVATIONS)
Greater Pittsburgh Airport, 1945-1965

Speed (knots) / Direction	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	56	%	Mean
North	0.3	1.3	1.6	0.5	0.0	0.0						3.7	7.3
NNE	0.4	1.4	1.3	0.3	0.0	0.0	0.0	0.0				3.5	6.8
NE	0.5	1.5	1.1	0.2	0.0	0.0						3.4	5.2
ENE	0.5	1.4	1.6	0.4	0.0	0.0						3.9	7.0
East	0.6	1.8	1.6	0.5	0.0	0.0						4.7	6.8
ESE	0.5	1.4	1.6	0.7	0.1	0.0	0.0	0.0				4.3	7.6
SE	0.6	1.8	1.7	0.6	0.1	0.0	0.0					4.7	7.1
SSE	0.5	1.5	1.4	0.4	0.0	0.0	0.0					3.8	7.8
South	0.6	1.7	1.6	0.5	0.1	0.0	0.0	0.0				4.4	7.0
SSW	0.4	1.4	2.0	1.3	0.3	0.1	0.0	0.0				5.4	8.9
SW	0.8	1.8	3.4	2.7	0.7	0.2	0.0	0.0	0.0	0.0		9.5	10.0
WSW	0.5	1.9	4.5	4.6	1.5	0.5	0.1	0.0	0.0	0.0		13.5	11.4
West	0.5	1.8	2.9	2.7	0.8	0.3	0.0	0.0	0.0			9.0	10.5
WNW	0.4	1.5	2.6	2.6	0.8	0.2	0.0	0.0	0.0			8.0	10.7
NW	0.3	1.4	2.3	1.7	0.4	0.1	0.0	0.0				6.0	9.4
NNW	0.3	1.2	1.9	1.1	0.1	0.0	0.0					4.8	8.7
CALM												7.4	
	7.8	24.7	32.9	20.6	4.8	1.3	0.2	0.1	0.0	0.0		100.0	8.3

Total number of observations was 176,927.

general, the "roughness effect" acts to decrease the mean wind speed due to frictional forces; at the same time, the local wind direction tends to become channeled along the orientation of the valleys. The overall result is to create a tendency for further concentration of pollutants in the valley areas occupied by industrial and highway sources. With this combination of unfavorable influences at work in the Greater Pittsburgh area since the middle of the 19th Century, there is little wonder that a serious air pollution problem has existed for a long time. Forbes Magazine for 15 November 1972 contains a photograph (p. 36) of Pittsburgh as it looked thirty years ago, before the clean air campaign took hold.

One favorable aspect of the distribution of industry and motor vehicle traffic in the Pittsburgh area is that, from the standpoint of one who is studying the air pollution problem there, the fact that population and pollution sources tend to be concentrated in the valleys at least allows him to focus his attention on these relatively small geographical areas. The 20 zones with the highest emission densities are listed in Table II-2. As can be seen by referring to Figures II-2 and II-3, they are clustered around the CBD. Zone 1 is the downtown Pittsburgh area, the "Golden Triangle." The zones contiguous to Zone 1 are 2, 9, 14, 16, and 17. Zones 1-20 are in the City of Pittsburgh. Zones 21-51 compose the rest of Allegheny County. In general, the higher the zone number, the farther it is from the "Point", but there are exceptions to this. (It is of some interest to note that the sequence of highest emission densities is not the same for HC as it is for CO; the reasons for this are not yet fully understood, although non-vehicular sources do play a larger part in HC emissions than they do in CO emissions.) The "zone"

TABLE II-2

EMISSION DENSITIES IN THE SPRPC REGION, 1972 and 1977 (kg/sq. mi.)

Showing the 20 highest zones in descending order of CO emission density.

1972			1977		
Zone #	**CO**	**HC**	**Zone #**	**CO**	**HC**
1	21,859.16	3113.65	1	10,975.53	1423.70
2	7,929.38	1159.65	16	4,419.27	579.63
16	7,373.80	1063.84	2	3,950.94	523.46
3	6,437.18	925.84	3	3,165.03	413.77
14	6,230.87	976.34	14	3,155.99	441.85
6	6,016.03	864.62	6	2,996.99	391.55
9	5,957.84	836.96	9	2,959.80	379.86
17	5,207.37	745.04	17	2,648.50	345.02
18	4,071.58	592.94	18	1,981.63	261.90
11	3,214.32	463.03	11	1,515.73	198.56
7	2,803.93	390.82	7	1,378.30	175.76
23	2,498.99	449.39	23	1,286.98	197.91
50	2,104.05	387.23	20	1,114.95	143.94
13	2,103.67	297.25	50	1,111.17	173.90
20	1,972.03	278.33	21	1,031.89	156.67
21	1,904.18	336.67	13	949.95	122.50
12	1,761.90	255.58	44	804.22	126.62
5	1,586.24	220.24	12	804.08	105.93
8	1,450.34	198.93	5	725.99	92.28
19	1,345.57	194.73	8	721.98	90.86

Source: computer program VEHEMI2, "no-strategy" case.

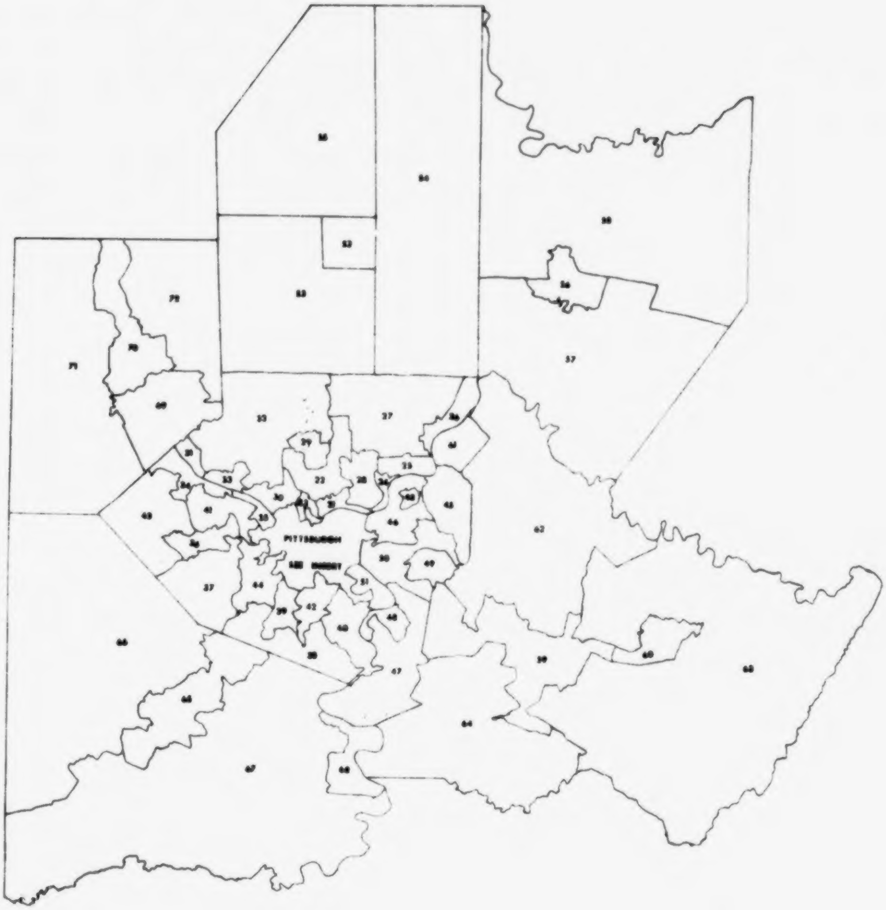

Figure II-2. Zone map, SPRPC region.

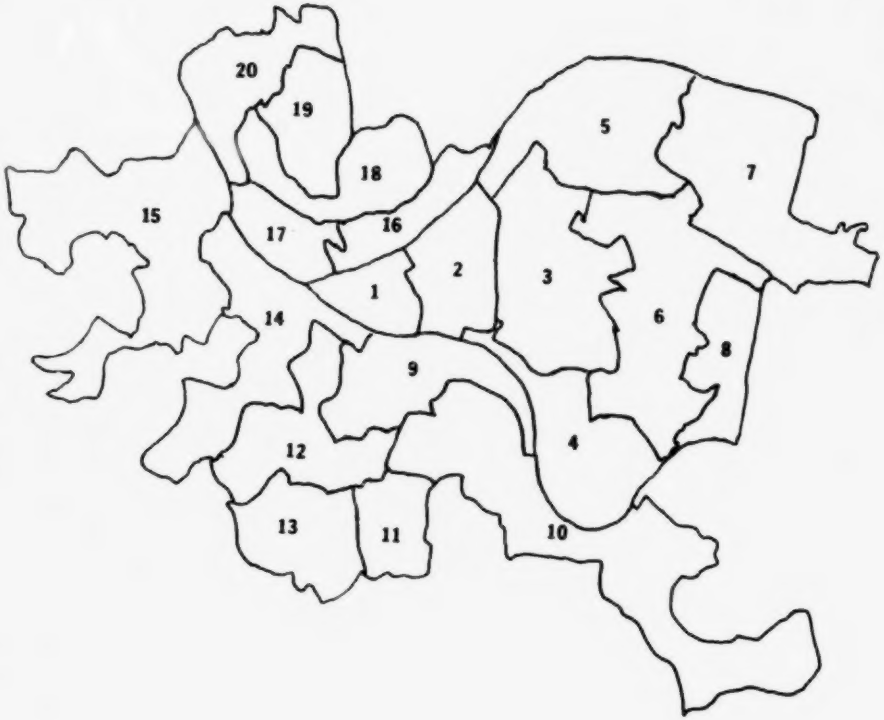

Figure II-3. Zone map, city of Pittsburgh.

terminology refers to the AMV Districts, which are aggregates of the Southwestern Pennsylvania Regional Planning Commission (SPRPC) Traffic Analysis Zones (see Figures II-2 and II-3).

2. Instrumentation

a. Sampling Locations

(1) General

While we have some data on CO, total oxidants, and total hydrocarbons (HC) from five different sites in the Greater Pittsburgh area (See Map, Figure II-4), close inspection of these data and consultation with personnel of the Allegheny County Bureau of Air Pollution Control (BAPC) have revealed that only the observations from the three sites discussed in detail below were both consistently accurate and of sufficient frequency over a significant period of time to form the basis for conclusions regarding the ambient air quality in the region. No data were abstracted from the other three stations of the BAPC telemetering network (nos. 2, 4, and 5 in Figure II-4).

(2) Downtown Pittsburgh (Zone 1)

The sensor is located on the Forbes St. (southwest) side of the Allegheny County Court House, about 15 feet above the street level and 20 feet in from the curb. Its position below a window of the Court House is about 50 feet from Grant Street. The recorder and other instrumentation are in a room of the Court House adjacent to the sensor location. Situated on the southeast side of the Golden Triangle, in the

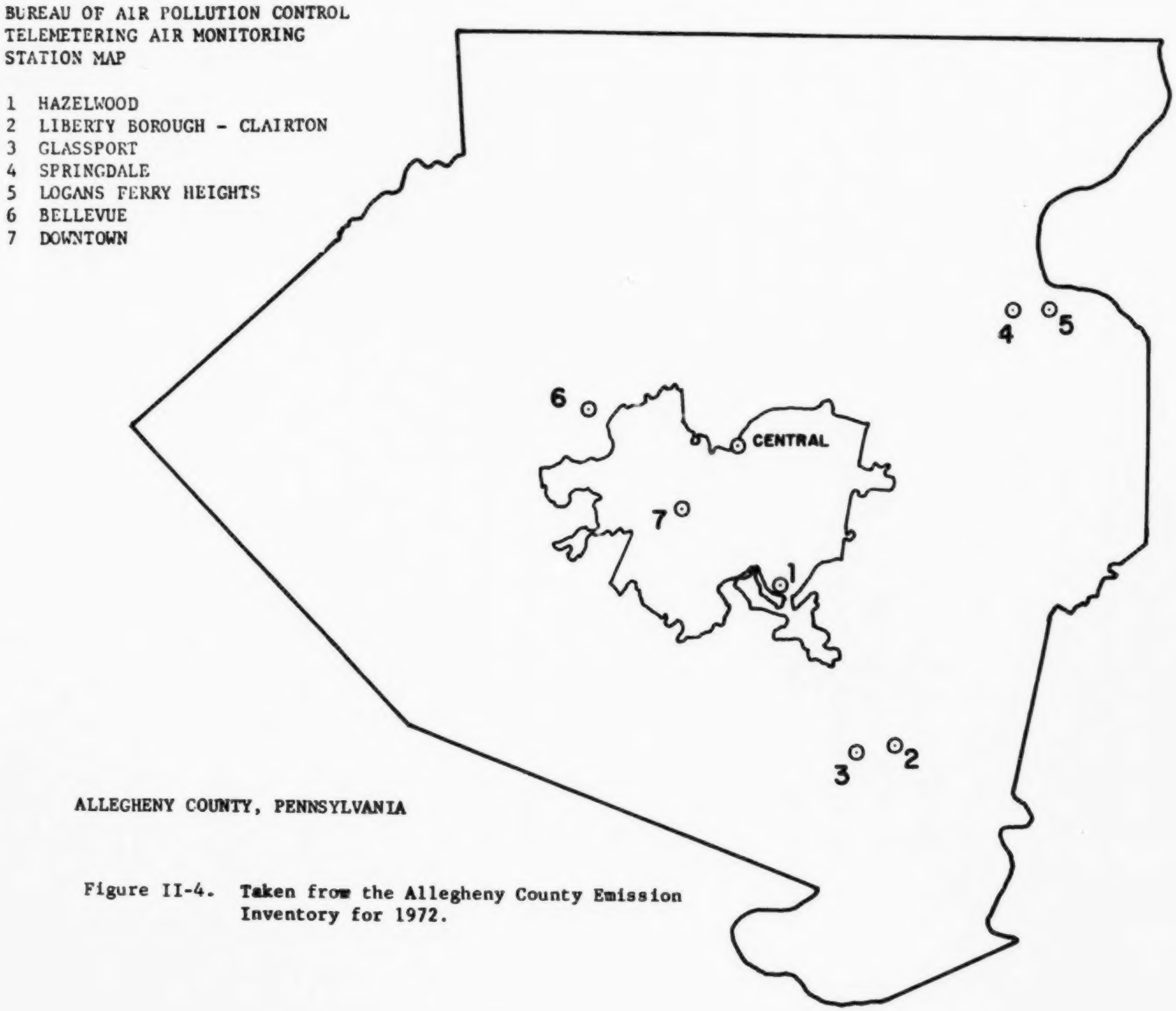
BUREAU OF AIR POLLUTION CONTROL
TELEMETERING AIR MONITORING
STATION MAP
1 HAZELWOOD
2 LIBERTY BOROUGH - CLAIRTON
3 GLASSPORT
4 SPRINGDALE
5 LOGANS FERRY HEIGHTS
6 BELLEVUE
7 DOWNTOWN
6
CENTRAL
7
1
4
5
3
2
ALLEGHENY COUNTY, PENNSYLVANIA

Figure II-4. **Taken from the Allegheny County Emission Inventory for 1972.**

very heart of downtown Pittsburgh, this location is well suited to give a true representation of the concentrations of CO and HC pollutants to be expected from the heavy vehicular traffic to which it is exposed. Given the general experience in most urban areas that practically all of the CO emissions (on the order of 90 - 95%) come from the internal combustion engine and that the vast preponderance (75 - 80%) of HC emissions also come from gasoline-fueled engines, this site is almost ideally located for purposes of a study of transportation-related air pollution. This is all the more true since, as will be discussed later, there is only one major point source located within Zone 1, the downtown area, and it contributes only about 0.2 ppm to the ambient concentration of CO. Since the sensing device is located on the wall of a high building there is a physical restriction of the sampling process: it is exposed to air from only one-half of the possible directions. On the other hand, the "roughness" concept as discussed in the preceding section with respect to the effects of terrain and underlying surface is equally applicable to urban areas with their many tall buildings and narrow, canyon-like streets. Indeed, the study of the eddy motions of all scales related to turbulence induced by urban built-up areas is a highly complex area of specialization in its own right and can only be acknowledged in passing here, important as it is in air pollution meteorology.

(3) Bellevue (Zone 30)

The sensor for this site (No. 6 in Figure II-4) is positioned on top of a camper-type trailer semipermanently parked on the north bank of the Ohio River on a high bluff about 200 feet above the water level and 30 feet in from the river bank below. The site is off of Ohio River Blvd. in the Borough of Bellevue, about 4 miles downstream (northwest) of the Golden Triangle. The height of the sensor above the ground is 20 feet; it is about 100 feet from the roadside, behind a steel fence which separates it from a gasoline service station. There is a possibility of some interference from the HC fumes emanating from the adjacent gas station, which is only some 40 feet away. Because of its high elevation and nearness to a major highway artery, the readings from this site should prove to be representative of the surrounding area as far as motor vehicular pollutants are concerned.

(4) Arsenal Health Center (Zone 2)

This is under the jurisdiction of the Allegheny County Health Department, the parent organization of the BAPC. The complex of buildings is located at the corner of 39th Street and Penn Avenue, in the Lawrenceville section of Pittsburgh near the Allegheny River. While this site is some three miles from the downtown area, it is still well within the built-up and highly industrialized area characterizing the city proper. As a matter of fact, it is situated not far from several large point sources (tank farms and the like) which are located along the south bank of the Allegheny within a mile of the Center. It is also located near a major arterial highway, but not close enough to be exposed to high concentrations of exhaust emissions from motor vehicles. This site was used only for measurements of ozone concentrations in this study, and its precise location with respect to the various sources is therefore not a critical matter as long as it lies generally downwind from them, since in the case of oxidants we are concerned more with the area-wide picture than with particular zones within the area. The sensing instrument was located 20 feet above the ground.

b. Type of Instrumentation

(1) Downtown Pittsburgh

The instrument used for the detection and measurement of CO concentrations is an MSA Lira non-dispersive infrared analyzer. It has a 25 cu ft/hr flow rate and a refrigerator to remove moisture. Sampling is continuous and is recorded at three minute intervals and telemetered to the Arsenal Health Center (see above). The room where the instruments are located is presently undergoing remodeling and they are covered with plastic sheets to prevent excessive dust from interfering with their operation. The effectiveness of these measures could not be assessed. It is expected that the instruments will be moved to a new location within the Court House, possibly on the Grant Street side. If this does occur, a new exposure will create some minor discontinuity in the records, but the effect, if any, on the overall efficiency of the BAPC operation should prove to be only slight.

A Mast instrument for measuring total oxidants was also installed in the equipment room; however, it had been shut down because of the danger to the historical site (the Old County Court House itself) represented by the hydrogen tank associated with the Mast instrument. In any event, the data from this and other oxidant-measuring instruments at other sites in the Pittsburgh area were not usable because they lay outside the range of possible values as oxidants are usually measured and reported for purposes of air pollution control.

(2) Bellevue

The same type of CO analyzer was installed at this site; the MSA Lira with refrigerant dryer to remove moisture from the air stream. As in the downtown location, sampling is continuous and the results are telemetered to the Arsenal Health Center at three minute intervals for data reduction. This instrument was down for parts at the time of our visit and had been so since 1 September 1972; it should be back in operation "shortly". The operating personnel had some difficulties with the air conditioner during the year that the installation was in operation. During the summer months the trailer housing the recorder and other instrumentation gets very hot, and the failure of the air conditioning produced some bad data. This station commenced operation in August, 1971, and the first full month's data are for September of that year. Thus, because of the shortness of the record, the data from the Bellevue site must be used with some caution. The CO data appear to be within reasonable limits, but those for total oxidants and total hydrocarbons, like the corresponding data from the downtown site and elsewhere, were not in useable form. In the case of the Bellevue site the possibility of interference from the nearby gas station has already been mentioned (for HC measurements).

(3) Arsenal Health Center

The reference method for determination of ozone concentrations, instrumental chemiluminescence, was used in the special study made by EPA and other agencies during the summer of 1971 to assist those cities which did not possess an adequate capability for monitoring oxidant levels. No information is available to us on the details of the equipment used or the level of the staff expertise. However, some additional information is included in the following section on the air quality data itself (see Section IIB 3c).

3. Review and Evaluation of Air Quality Data

a. General

Some general comments on the regularity, validity, and reliability of the available data have already been made in the preceding sections. As stated previously, the CO data were uniformly good, with only one or two "far-out" observations recorded. On the other hand, the O_x and HC data from the stations listed below were not available in useful form because the results tabulated were "out of range" for the expected values of "HC corrected for methane" and "oxidants as ozone," respectively. The several tables of these data are not reproduced in this report, since they do not add anything of value and are quite voluminous. In any event, they are already available to the various interested agencies. Some of the possible reasons for the results appearing in this form have been treated in the section on instrumentation.

Type of Pollutant	Name of Station	Ref. No., Figure II-4	Period of Record
Carbon Monoxide (CO)	Downtown	7	Mar 71-Aug 72
	Bellevue	6	Apr 71-Aug 72*
"Oxidants" and "total oxidants" (O_x)	Bellevue	6	Apr 71-Aug 72*
	Glassport	3	Apr 71-Aug 72
	Hazelwood	1	Apr 71-Mar 72
Ozone	Arsenal	"Central"	Jun 71-Sep 71**
"Total hydrocarbons" (HC)	Downtown	7	Apr 71-Feb 72
	Bellevue	6	Oct 71-Oct 71

(No data from the Logan's Ferry, South Allegheny (Liberty), or Springdale stations.)

*The trailer-mounted instruments were originally set up at the Arsenal Health Center (39th St. and Penn Ave.) and were moved out to the present site in Bellevue in August, 1971.

**These data were taken by the EPA-MITRE Summer Study project (see below).

b. CO Data

An analysis of the usable CO data from the two sites described in Section IIB 2a, above, for the periods shown in Section 3A yielded the results summarized in Table II-3. The curves in Figures II-5 and II-6 show the seasonal and diurnal variations in maximum intensities. Complete tables of maximum 1-hour CO concentrations are included as Appendix A.

As can be seen, both the 1- and 8-hour average concentrations of CO in downtown Pittsburgh have exceeded the approved national standards. The highest recorded 1-hour average concentration of CO as measured at the sensing device for Zone 1 (AMV District 1) is 44.2 ppm and the second highest is 38.6 ppm for the period of record. The required reduction of 20.8 percent from the highest reading can easily be attained

TABLE II-3

Station	Zone	Averaging Period	Highest ppm	Highest Date	2nd Highest ppm	2nd Highest Date	Federal Standard ppm	Reduction Required* (%)	
Downtown	1	1-hour	44.2	1 Oct 71	38.6	3 Nov 71	35.0	20.8	9.3
		8-hour	21.3	18 Nov 71	21.2	2 Oct 71	9.0	57.8	57.6
Bellevue	30	1-hour	37.3	14 Sep 71	35.3	15 Dec 71	35.0	6.2	1.0
		8-hour	20.6	29 Feb 72	20.0	24 Feb 72	9.0	56.3	55.0

*If the Federal standard could be met by neglecting non-vehicular emissions.

Summary of Data for Ozone for the Period 1 June - 30 September 1971:

Arsenal	2	1-hour	0.165	28 Jun 71 (1200)	0.155	28 Jun 71 (1300)	0.08	51.5	48.4

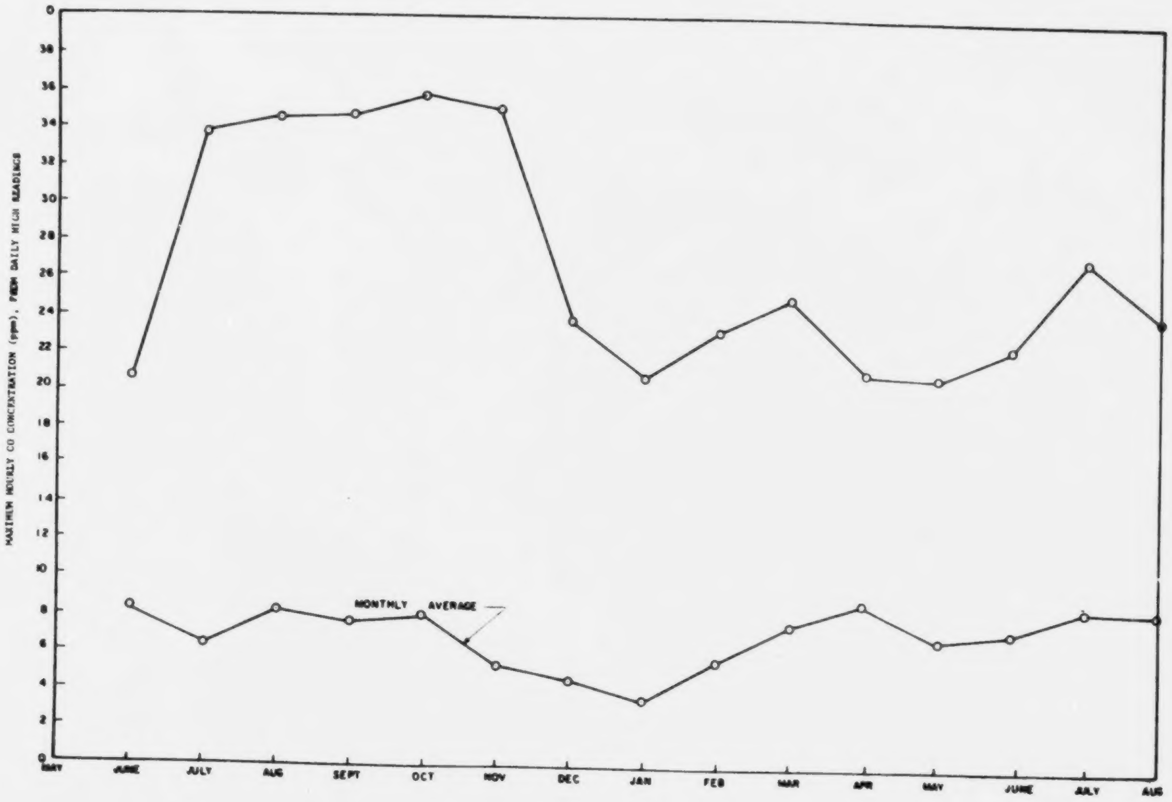

Figure II-5. Monthly variation in maximum hourly CO concentration downtown Pittsburgh. Monthly average also shown. (Value plotted is average of two highest readings for the month.)

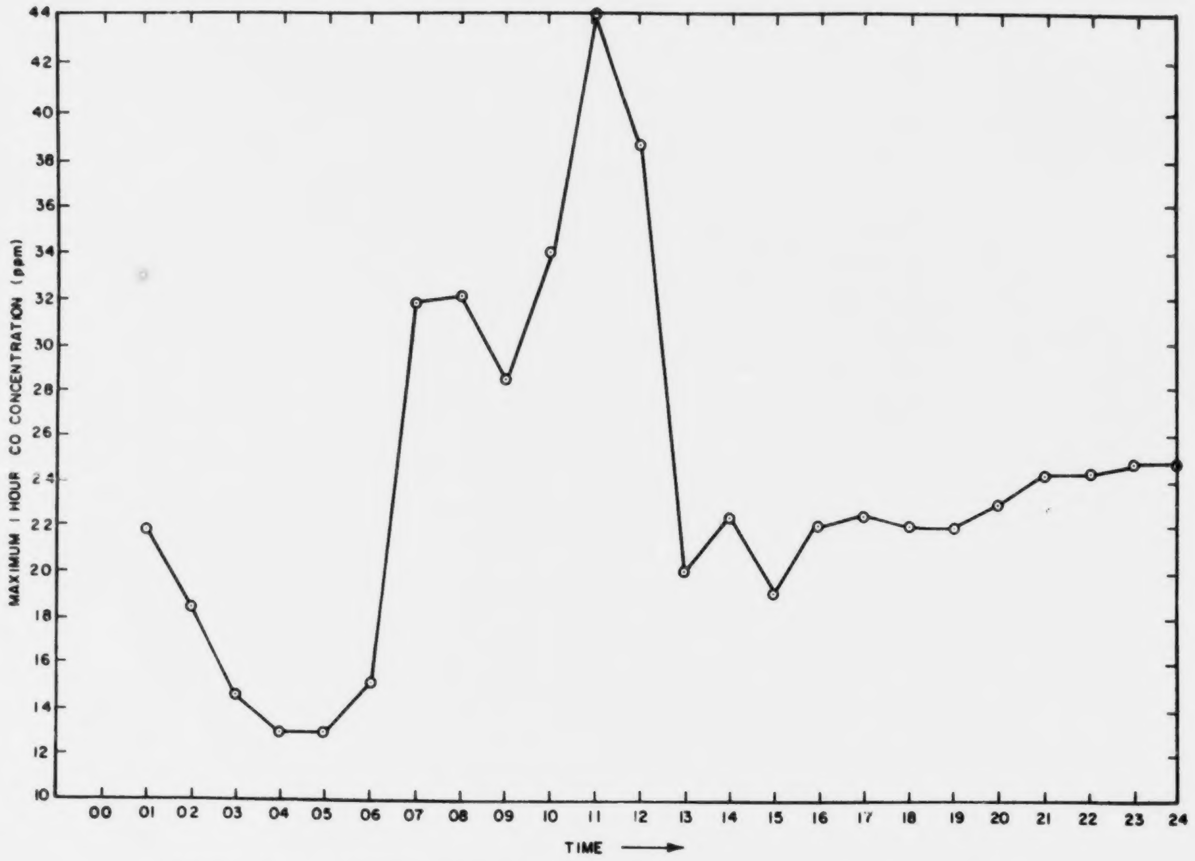

Figure II-6. Diurnal variation in hourly maximum CO readings (downtown Pittsburgh).

as a result of the operation of the presently authorized and required Federal program for control of emissions from motor vehicles. Even though the presence of emissions from non-vehicular sources would act to prevent the desired standard from being achieved if this amount of reduction were just barely reached, there is sufficient leeway in the expected results of the Federal program, as will be shown later, to insure that the 1-hour standard can be met. The problem arises when we look at the 8-hour averages: the highest recorded thus far at the Zone 1 site is 21.3 ppm and the next highest is 21.2 ppm (see Table II-3 above). These are more than twice as large as the Federal standard and require a reduction in vehicular emissions (under the same assumption of negligible non-vehicular emissions) of 57.8 percent and 57.6 percent, respectively. These are not attainable through the present Federal program; thus, a transportation control plan for the downtown area must be instituted in order to bring the level of CO concentration down to the standard by 1977. It must be emphasized here that the above reduction percentages are not the actual figures required to attain the standards. As will be shown in a later section, the non-vehicular emissions cannot be neglected and the reduction percentages must be figured based on total emissions, not just vehicular ones.

Since the control strategy required to reduce high 8-hour CO concentrations may depend on the time of day or the season of the year when they occur most often, the data were analyzed to determine, if possible, the patterns of interest. The 1-hour averages were directly available from the raw data (see Appendix A), but the 8-hour values had to be computed from the 1-hour data. The method used was to scan the raw data for "runs" of high hourly values, then add successive overlapping 8-hour series to obtain the candidates for highest 8-hour average concentrations. As can be seen from the table below (Table II-4), this technique produced several values which were nearly the same. Thus, conclusions as to time of maximum 8-hour concentration are apt to be based on somewhat shaky ground if it turns out that the high values are more or less randomly distributed through the day and through the year. Moreover, with only one year's record available for analysis, it is not really valid to assume that it is typical of the long-term period in which we are interested (out to at least 1977). With these caveats in mind, we can state, at least tentatively, that the diurnal cycle of CO concentration seems to be displaced in Pittsburgh from the early morning or nighttime maximum usually found elsewhere (see Figure II-6). Based on these limited data, the maxima at both sites appear in the late morning hours; similarly, whereas the common experience in most areas has been that the highest concentrations of CO occur generally in the late fall and winter months, it appears from these data that the annual maximum can be found in the early fall in and around Pittsburgh (Figure II-5). The reasons for this apparent departure from the distribution to be expected on the basis of previous experience are not immediately apparent; it may be that additional data from future months and years, especially if the instrumentation and technical staff are maintained at a high level of efficiency, will enable us to ascertain the true patterns of annual and diurnal variation. About all that can be said with any degree of confi-

TABLE II-4

HIGHEST RECORDED 8-HOUR AVERAGE CONCENTRATIONS (CO), PITTSBURGH, ZONE 1

DATE	HOURS	8-HOUR AVG. CONCENTRATION (PPM)
18 Nov 1971	07-14	21.27
2-3 Oct 1971	20-03	21.2
29 Feb - 1 Mar 1972	18-01	20.9
14-15 Dec. 1971	18-01	20.4
	19-02	20.4
1 Oct 1971	08-15	20.4
17-18 Nov 1971	17-24	19.8
18 Aug 1971	07-14	18.7

HIGHEST RECORDED 8-HOUR AVERAGE CONCENTRATIONS (CO), BELLEVUE, ZONE 30

DATE	HOURS	8-HOUR AVG. CONCENTRATION (PPM)
29 Feb-1 Mar 1972	19-02	20.6
24 Feb 1972	11-18	20.0
14-15 Dec 1971	17-24	19.1
	18-01	19.1

dence at this time is that there is a greater frequency of high 8-hour average concentrations of CO in the late afternoon and evening (1800 to 0200 hrs) than at other times, although even this generality is based on extremely limited data.

An interesting picture is presented by the histogram in Figure II-7, which displays the number of daily maxima of hourly readings of CO concentration in Zone 1, by hour. The morning and evening rush hour traffic shows up clearly and several secondary features also appear. This is an excellent example of the way in which the driving habits and life styles of a city's residents are faithfully reflected in the diurnal variation in the concentrations of its atmospheric pollutants. Without stretching the point too far, one could deduce something about the times of day when most Pittsburghers go to work (between 0700 and 0900), when the ladies do their shopping or meet friends for lunch (around 1100), when the people who work in the downtown area go home for supper (1600 to 1800), when they go out to eat or to a movie, perhaps (2000 to 2100), and when they return home again (2300 to 2400). Even the relative shape of the frequencies is preserved: one can equate the "early shift" (0700) to the early quitting time (1600), and so on.

c. Oxidant Data

As stated earlier, the oxidant data obtained from the BAPC were found not to be useful for the present study. Fortunately, a special study was carried out during the summer of 1971 by the EPA and several of the State and local agencies with the assistance of the MITRE Corp-

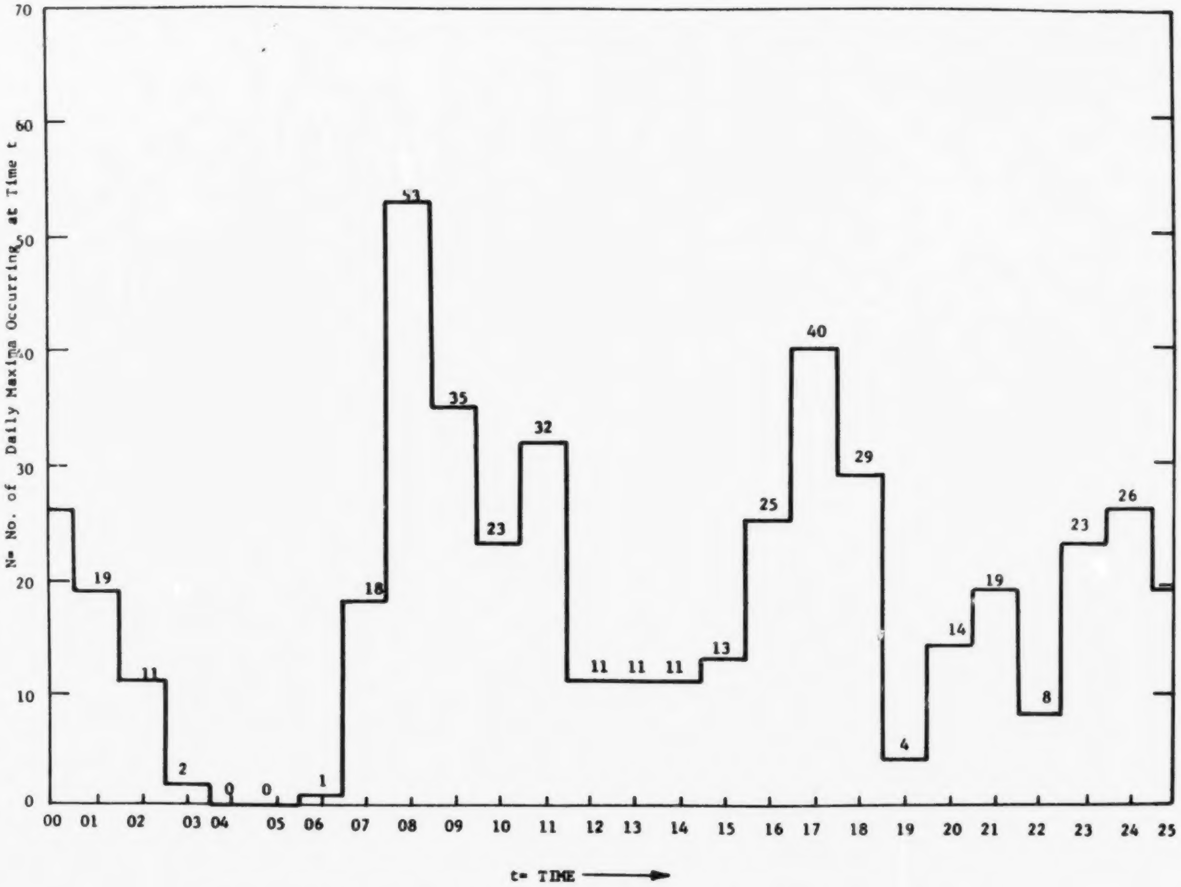

Figure II-7. Hourly frequency of daily maximum CO concentration June, 1971 to August, 1972.

oration to determine concentrations of ozone (O_3) in cities lacking a capability to monitor ozone adequately but large enough to pose a putative oxidant problem. Fortunately again, Pittsburgh was among the 33 cities included in this study. As stated previously, the site selected in Pittsburgh was well located with respect to the greatest ambient concentrations of hydrocarbons, in that it lies some 3 miles to the northeast of the downtown area. As shown in the computer printout of vehicular emissions of HC for 1972 and 1977 (see Appendix C), the downtown area (Zone 1) has by far the greatest output per unit area of HC (and CO) from motor vehicles. Given the strong prevalence of westerly to southwesterly winds in the Pittsburgh area (Table II-1), it is at once apparent that the Arsenal was an excellent choice.

Ambient ozone concentrations were measured continuously, using the reference method (chemiluminescence) as prescribed by the EPA in 40 CFR 50, Appendix D, Federal Register, Vol. 36, No. 228, 25 November 1971, pp. 22392-22394. Hourly average values of O_3 concentration were recorded and collected by the EPA; these data were validated by cross-reference to weekly summary data. In this manner, obvious errors in hourly data were removed and a good set of data was made available to the various agencies for their use in preparing the Implementation Plans for submission to the EPA. Since the original data sheets contain a great deal of information not pertinent to the present study, only the daily maxima and hourly frequency of highest readings are reproduced in Table II-5 and Figure II-8A, below. The last line in Table II-3, above, summarizes the most important

TABLE II-5

MAXIMUM 1-HOUR OZONE READINGS - ARSENAL HEALTH CENTER

Period of Record: 1 June - 30 September 1971. Method: Chemiluminescence
Monthly highs and 2nd highs are underlined.

					Time of daily high reading				Frequency		
Day	June	July	Aug.	Sept.	June	July	Aug	Sept	Hr.	#	Times Ex **
1	.070	(ND)	.055	.075	16,18	(ND)	17	14-16	01	0	0
2	.045	(ND)	.040	.060	18-19	(ND)	13	13-14	02	0	0
3	.055	(ND)	.020	.045	18-19	(ND)	13-14	13-14	03	0	0
4	.090	(ND)	.020	.050	12	(ND)	16-17	16-17	04	2	0
5	.085	(ND)	.045	.070	14-15	(ND)	12-13	12-13	05	1	0
6	.095	.085	.080	.050	15	16,19-20	16	14-15	06	2	0
7	.055	.100	.110	.040	13	15	17-18	14-15	07	0	0
8	.055	.090	.100	.055	12-13	13	14	16	08	0	0
9	.040	.100	.120	.090	15	17-18	15	12-14	09	0	0
10	.065	.070	.085	.095	17	15	13-14	13	10	0	0
11	.085	.050	.060	.030	14,16	17-18	18	18	11	1	1
12	.045	.050	.080	.020	16	17-18	17-18	04,22-23	12	8	7
13	.070	.070	.135	.030	13-14	19	17	18	13	20	12
14	.065	.070	.095	.025	18	20	15	17-18	14	35	15
15	.030	.075	(ND)	.060	14-16	19	(ND)	15,17-18	15	36	15
16	.055	.080	.055	.025	17-18	14	15-18	00*	16	25	16
17	.075	.025	.080	.020	16	19-20	15-16	13	17	24	13
18	.050	.050	.105	.020	15	14	16	14-18	18	22	11
19	.055	.065	.075	.015	14-16	14-15	15	14	19	0	10
20	.085	.050	.055	.020	16	18	15	11-14	20	2	4
21	.060	.075	.070	.030	14	16	15	14	21	0	1
22	.065	.105	.055	.030	16-17	15,19	14	13-15	22	1	0
23	.080	.075	.045	.030	14-15	13,19	17	18-19	23	1	0
24	.075	.045	.045	.030	17	13	15-18	14-17	24*	3	0
25	.095	.095	.070	.040	15	19	14	15-16			
26	.065	.075	.035	.015	15	00*	16	04-06			
27	.090	.055	.040	.025	16-17	17-18	15	14-15			
28	.165***	.065	.050	.035	12	14	14	13-16			
29	.105	.035	085	.040	15	00,06	17	14-16			
30	.070	(ND)	.080	.035	12	(ND)	18	14,17			
31		(ND)	.145			(ND)	15				
Avg.:	.071	.069	.071	.040							

TOTAL: 105 times

*00 hrs = 24 hrs

**No. of times the std. of 0.08 ppm has been exceeded.

JUN: 36/701=5.14%
JUL: 24/512=4.69%
AUG: 37/696=5.32%
SEP: 8/720=1.11%
AVG: 105/2629=3.99

***The second highest reading, 0.155, occurred the hour following this one.

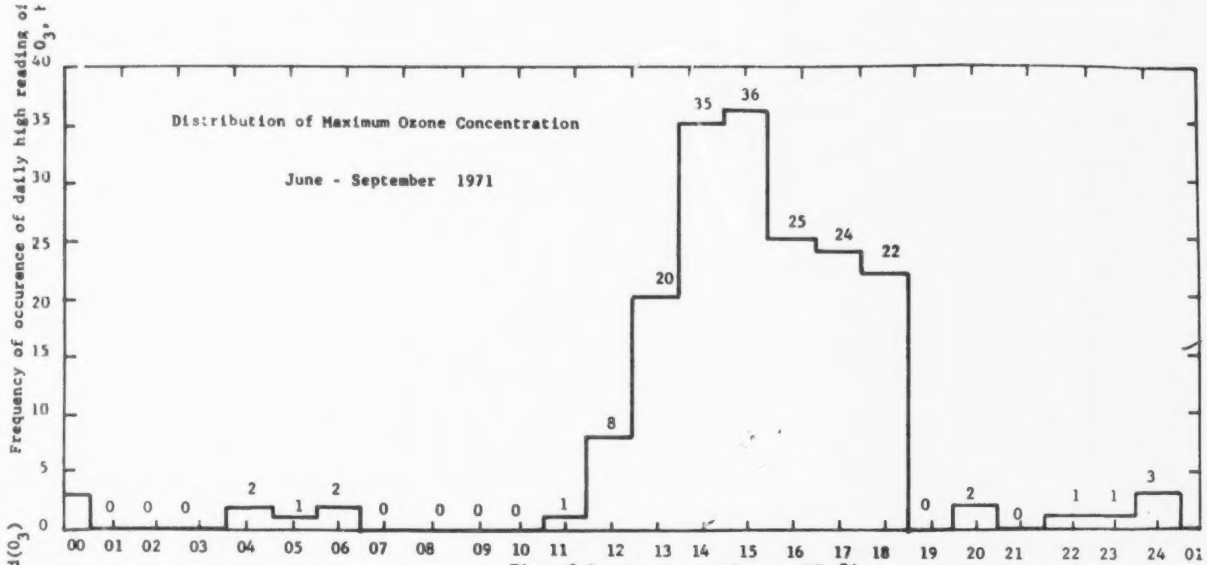

Figure II-8A.

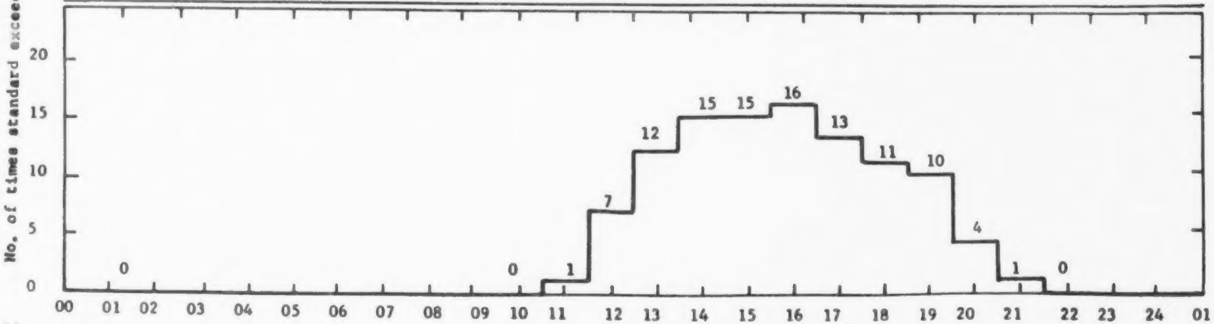

Figure II-8B.

findings needed to form a basis for the determination of the amount of "rollback" required to meet the Federal standard.

The data clearly show both the expected summer-time seasonal maximum and the commonly observed diurnal maximum beginning in the late morning to early afternoon. Figure II-8B depicts the number of times that the Federal standard for oxidants has been exceeded during the four-month period. The corresponding data for CO were not available at the time of preparation of this report. Here also the summer-time maximum is clearly visible, both as regards absolute maximum values and frequency of measurements exceeding the standard. It is felt that, given the care with which these data were generated, even though only one season is represented, they form an adequate basis for forming conclusions as to the likelihood of Pittsburgh's experiencing an oxidant problem within the next few years. In particular, since we are concerned in the case of photochemical oxidants with an area-wide average concentration rather than a localized one, the approach used here seems to be the best that could be devised for the present purpose. As will be discussed at greater length in a later section, the situation in Pittsburgh, based on the information in the bottom line of Table II-3, appears to be that no serious oxidant problem can be expected to persist once the Federal program and the strategies for reduction of CO emissions have been instituted.

Of the 33 cities included in the Summer Study, Pittsburgh ranked fourth in highest level of O_3 concentration measured and fifth in the number of times that the standard was exceeded. In absolute terms, the highest concentration recorded anywhere during the study was 0.190 ppm (at Corpus Christi, Texas, Dayton, Ohio, and Milwaukee, Wisconsin), not too far above Pittsburgh's 0.165, while the standard was exceeded no less than 168 times in Dayton, 156 times in Toledo, Ohio, 112 times in Columbus, Ohio, 110 times in Rochester, New York, and 105 times in Pittsburgh.

C. DISCUSSION OF 1972 AND 1977 VMT

The following methodology describes resources, assumptions and analysis techniques used to calculate the data needed to estimate vehicle emissions for the Southwestern Pennsylvania Region. This region is defined to include the City of Pittsburgh and the Counties of Allegheny, Armstrong, Beaver, Butler, Washington and Westmoreland. This region covers approximately 4,500 square miles of land and has a present population of approximately 2.6 million people. In order to facilitate the analysis, the region was divided into 72 districts. Figures II-2 and II-3 delineate the district boundaries. The data required to estimate vehicle emissions by district include:

(1) Vehicle miles of travel (VMT*) by time period where the time periods are Peak Hour, Peak Twelve Hour, and Daily.

(2) Age distribution by vehicle type where the vehicle types are classified Light Duty Gas,

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*VMT is defined as the number of vehicles travelling on a given segment of roadway multiplied by the length of that roadway.

Heavy Duty Gas, and Heavy Duty Non-Gas. Light duty vehicle is defined as a vehicle weighing less than 6,000 pounds.

(3) Percent of VMT generated on each type of highway facility where the facility types are classified Freeway, Arterial and Local.

(4) Average vehicular speed by facility type by time period.

(5) Percent of VMT generated by type of vehicle.

The base information needed to calculate the required data listed above was collected from different sources which are specified in this report. The methods used to estimate each of the five sets of data needed are described in the ensuing paragraphs in the identical order that they are listed. The major contributor of data is the Southwestern Pennsylvania Regional Planning Commission. The data supplied by the Commission was reviewed by the Consultant and found to be the best available data which would satisfy the study's requirements.

It is assumed that some additions to the existing transportation system will be made by 1977. Highway improvements falling into this category are the completion of I-79. Short range transit improvements contributing to a modal split increase of 5 percent for trips destined to the CBD were also assumed.

The data base used in estimating 1972 and 1977 vehicle miles of travel by district for the Southwestern Pennsylvania region was derived from traffic assignments simulated by the Southwestern Pennsylvania Regional Planning Commission, SPRPC. 1967 was used as the base year, and the trip generation, distribution, modal split and assignment models were calibrated to survey data. The models were then applied to regional input totals for the projection year 2000, and the result was a 2000, Cycle I, traffic assignment. The links in the highway network were then identified with one of the 968 SPRPC zones in the region. The Interzonal VMT was then calculated by zone by summing the VMT for all the links in each zone by the following equation:

$$VMT_i = \sum_{j=1}^{N} D_j \, ADT_j$$

where:

VMT_i = Daily Interzonal VMT for zone i

D_j = Length of link j

ADT_j = Simulated daily traffic for link j

N = Number of links in zone i

The next step was to aggregate the zones into districts. This aggregation of zones into districts was based on:

(1) Topology

(2) Meteorology

(3) Political Jurisdiction

(4) Similar VMT Density

(5) A Minimum District Area of One Square Mile

The aggregation reduced the 968 SPRPC zones to 72 districts with areas ranging from 1.21 to 513.30 square miles with an average district area of approximately 63 square miles. The interzonal VMT for all zones in a district were summed for 1967 and 2000. At this point, reasonable estimates of interzonal VMT by district were known for 1967 and 2000.

In order to arrive at 1972 and 1977 estimates of interzonal VMT by district, methods of interpolating the 1967 and 2000 interzonal VMT data were analyzed. The first method used SPRPC zonal population equivalents for each district to apportion county VMT increases between 1967 and 2000 to district increases. This method underestimated VMT growths for districts containing high volume transportation facilities and for districts with modest population-employment growths and a high percentage of through trips. Similar results occurred when a population plus growth factor was used. Appendix E details the algorithm used and describes its inadequacies.

The method selected to estimate 1972 and 1977 interzonal VMT by district from 1967 and 2000 data was to linearly interpolate the data by district. This method assumes a constant annual growth in VMT for each district and unlike the first method, it does not severely underestimate growths for districts with high volume transportation facilities or a high percentage of through trips. At the same time it does not underestimate VMT increases for districts which experience large population and employment growths from 1967 to 2000. These growths are inherently accounted for in the trip generation model. Overall, the linear interpolation of VMT by district reflects transportation demand and supply changes for each district. The following equations were utilized.

$$(j\ VMT_{2000} - j\ VMT_{1967}) \times \frac{5}{33} = \Delta VMT_j$$

$$j\ VMT_{1972} = j\ VMT_{1967} + \Delta VMT_j$$

$$j\ VMT_{1977} = j\ VMT_{1972} + \Delta VMT_j$$

where:

j = District being analyzed

$j\ VMT_{2000}$ = Interzonal VMT for district j for 2000

$j\ VMT_{1967}$ = Interzonal VMT for district j for 1967

$j\ VMT_{1972}$ = Interzonal VMT for district j for 1972

$j\ VMT_{1977}$ = Interzonal VMT for district j for 1977

ΔVMT_j = Five year interzonal VMT growth for district j.

Upon completion of the interpolation, interzonal VMT for 1972 and 1977 by district were known.

A factor was then applied to the interzonal VMT for all districts in a county in order to include VMT generated by intrazonal trips. The number of intrazonal trips was derived from SPRPC's base year assignment. Based on the data available, the estimation of intrazonal VMT was calculated on the county level. The number of intrazonal trips multiplied by average trip length resulted in intrazonal VMT. The intrazonal VMT for the county was then added to the base year interzonal VMT previously calculated. The ratio of total VMT to interzonal VMT was then calculated. The appropriate county ratio was then applied to the 1972 and 1977 interzonal district VMT's in order to arrive at total VMT by district for 1972 and 1977. These ratios varied from 1.0056 to 1.0520.

After reviewing traffic counts in different locations throughout the region, it was estimated that 75 percent of the daily VMT occurred during the peak 12-hours of the day and that 10 percent of the daily VMT occurred during the peak hour. These factors were applied to the district VMT totals and the result was the completion of estimating VMT by district for all three time periods for 1972 and 1977. The methodologies for the four remaining sets of required data follow in the next paragraph in the same order as they were listed.

The age distribution of passenger cars and trucks in operation by county as of July 1, 1971, was received from R. L. Polk. The percents of VMT traveled in each district via freeway, arterial, and local facilities were summarized from SPRPC's base year highway assignment. District peak hour and off-peak hour speeds for each of the three facility types were similarly derived from the base year assignment. The VMT estimates for heavy duty gas and heavy duty non-gas vehicles were derived from 1967 base year data. The VMT traveled by heavy duty gas and non-gas vehicles were estimated by county. The VMT generated by these types of vehicles by county were based on the mean truck trip length for the region, and on the heavy duty truck trip ends produced and attracted in each county. The mean truck trip length multiplied by the number of truck trips in the county resulted in Truck VMT. The VMT estimated for heavy duty gas and non-gas vehicles for the base year for each county were then divided by the total base year county VMT estimates, and the resulting percentages were applied to 1972 and 1977 VMT estimates.

Appendix D summarizes the results of the analysis just described. Vehicle miles of travel are listed by district for 1972 and 1977 by facility and vehicle type for each time period analyzed. Also listed are average vehicle speeds by facility type, district and time period.

Figures II-9 and II-10 show the district VMT densities as a function of their distances from the CBD for 1972 and 1977, respectively. Also shown in each figure is a non-linear approximation of the function. Figure II-11 compares the 1972 and 1977 non-linear approximations.

In further elucidation of the VMT question, the following information is reproduced from the Annual Report Issue (September, 1971) of the SPRPC Reports with the kind permission of Mr. Robert Kochanowski of the SPRPC Staff.

TRANSPORTATION PLANNING

Transportation planning activities during the past year have been primarily in technical work preparatory to the development of the transportation plan. This work is a necessary and important part of the transportation planning process. The major work activities follow:

Accuracy Checks

During the past year a series of accuracy checks were completed on data from various SPRPC surveys. The purpose of this job was to establish the validity of the data collected as a basis from which to forecast future activities and travel in the region. Included among these were

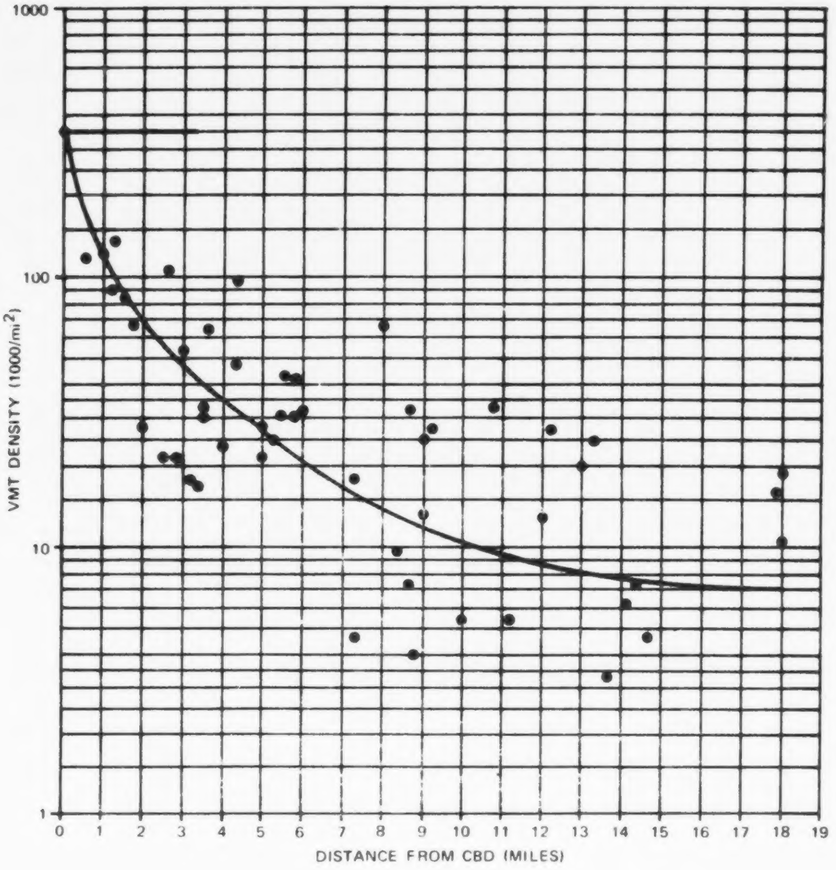

Figure II-9. VMT density (1000/mi^2) vs. distance from CBD (miles) Pittsburgh 1972.

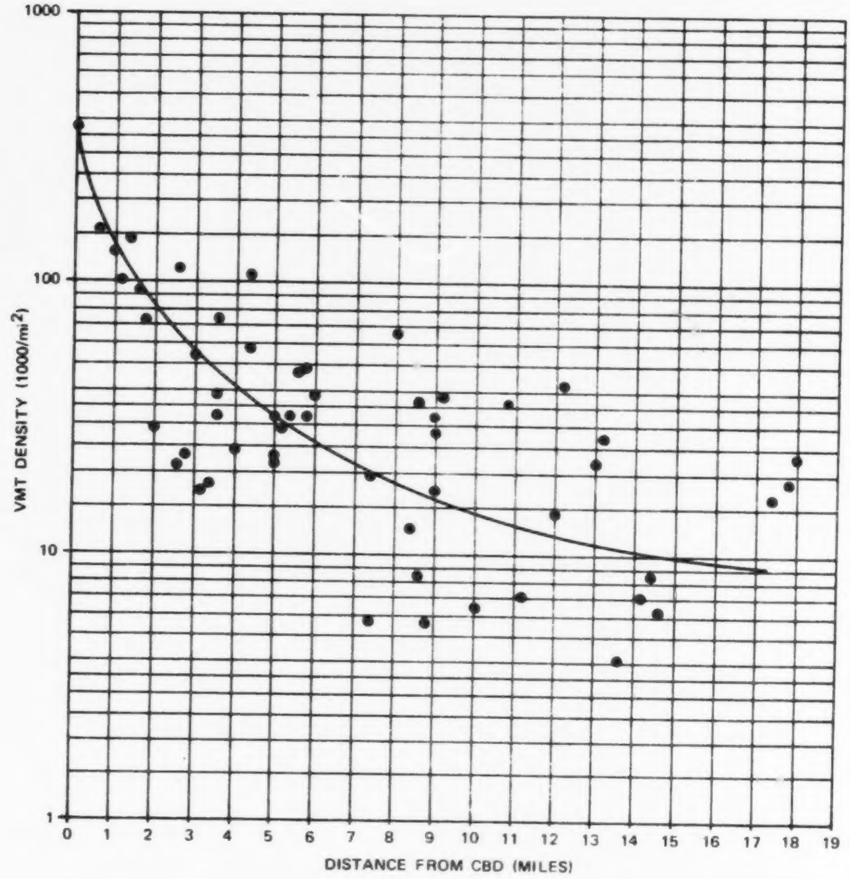

Figure II-10. VMT density ($1000/mi^2$) vs. distance from CBD (miles) Pittsburgh 1977.

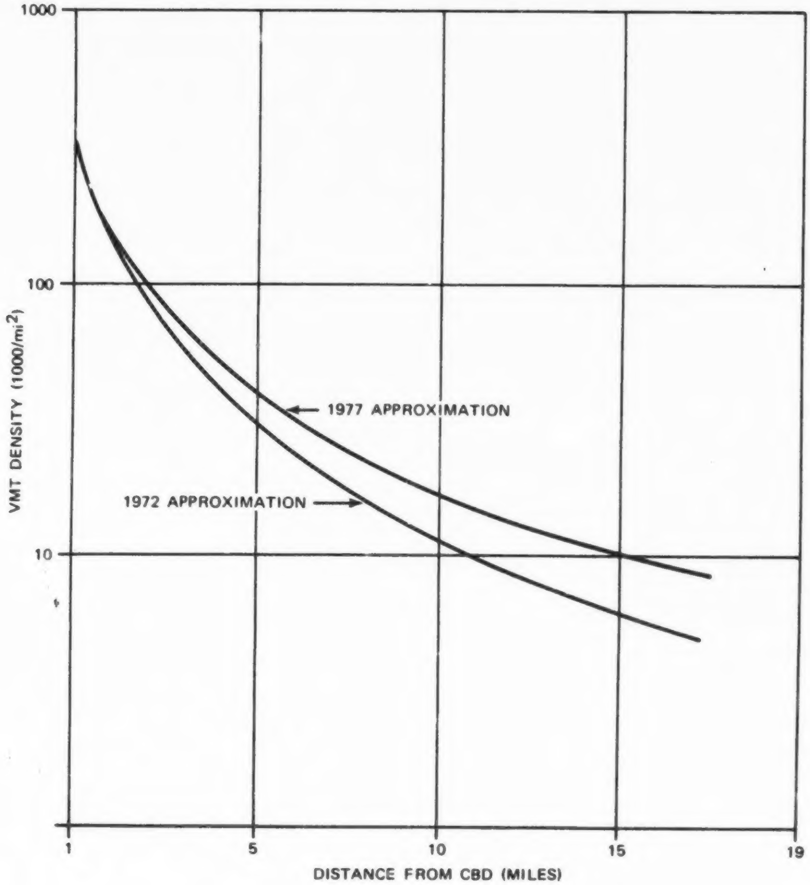

Figure II-11. 1972 and 1977 VMT density (1000/mi^2) vs. distance from CBD (miles) Pittsburgh.

checks of employment, dwelling units, population and automobiles available. One of the most significant checks is called the Screenline Check. This check establishes the accuracy of the trip data by making a traffic assignment of all vehicle trips reported in the travel surveys and comparing the assigned traffic volumes on major bridges in the region with traffic counts taken at these same locations. The results of these various accuracy checks have established that the base year survey information meets the required quality standards and can be used for transportation planning.

Highway and Transit Networks

One of the most important tools in the transportation planning process is traffic assignment. By using traffic assignment, future highway and transit trips can be assigned to proposed networks and the assigned volumes evaluated to determine the user demand characteristics of proposed systems. But before traffic assignments can be used with confidence to test future systems, the base year highway and transit networks must simulate existing traffic volumes. This is accomplished by coding the existing networks in a form acceptable for computer application and then assigning existing highway and transit trips from the travel surveys. Minor adjustments are then made to the existing network until the desired degree of simulation accuracy is achieved.

Trip Generation Models

Trip generation is the process of developing mathematical relationships between the amount of travel produced (going) and attracted (coming) in each traffic zone of the region, and the factors which are most directly related to the reasons for this travel. Equations are developed with base year data and are then used to forecast travel for the year 2000.

Trip Distribution Models

Trip distribution is the process of linking up the person trip productions and attractions that are developed for each zone in trip generation to produce tables to trip movements from zone to zone. The model used for trip distribution at SPRPC is called the Gravity Model and it operates on the general principle that trips between two zones are directly proportional to the size of the zones and inversely proportional to some function of the travel time between them.

Modal Split Models

When the steps of trip generation and trip distribution have produced a table of future travel, the next question that must be answered is which transportation modes will these people choose? The modal split model is developed to answer this question and to determine what percent of persons will ride transit in the planning year. At SPRPC the modal split model work has been divided into two parts. The first part is the development of a model to predict captive transit ridership. (A captive transit trip is a transit trip made by a person who did not have the choice to go by auto at the time his trip was made.) The captive model predicts the number of captive transit trips by relating them to such factors as auto ownership, density of development and the level of transit service available as represented by accessibility to desired destinations. The second part of the SPRPC modal split work is the choice model (for persons who have the opportunity to choose between transit and auto). The transit trips predicted by the captive and choice modal split models will then be assigned to coded future transit systems for testing and evaluation.

TOPICS Planning

SPRPC has contracted with the City of Pittsburgh and PennDOT to undertake a TOPICS planning program for the City of Pittsburgh, TOPICS being a federal highway program that is designed to improve the capacity and safety of existing arterial streets in urban areas. SPRPC's staff have been working with the City of Pittsburgh's staff in developing a series of recommendations for short range improvements on city streets and state roads within the City. These will be published in the form of an early action report. In addition, a second phase of TOPICS planning involves the adaption and adjustment of a model which will be used to evaluate such possible improvements as one-way street systems within the Golden Triangle or the impacts of major new traffic generators on traffic patterns. (End of quoted material.)

D. DERIVATION OF 1977 AIR QUALITY LEVELS

1. Present and Projected Non-Vehicular Source Emissions

a. Point Sources

All data used in this section were based on information contained in Pennsylvania's Implementation Plan, the Allegheny County Emissions Inventories for 1971 and 1972, and the results of meetings and discussions with personnel of the Allegheny County Health Department BAPC and the SPRPC.

A summary of the available data on point sources in and around Pittsburgh is presented in Table II-6. Although this information is fragmentary, it supposedly includes all major point sources within the County and to that extent may be taken as at least an indication of the distribution of non-vehicular emissions of CO and HC in that area of 745 square miles. The "Zone" column again refers to the AMV Districts which are shown in Figures II-2 and II-3. Details of plans for control of industrial emissions, other than those included in the tabulation of the "major point sources", and the number of new industrial installations to be built during the period of interest, are not known at this time, although a very general indication of growth rates is included in the IBM Study prepared for the EPA in February, 1972 (see references). According to this document, point sources (primarily industrial sources) in the Pittsburgh area are expected to "grow" at a negative rate of 7.7 percent, or about -1.54 percent per year, for the period 1970 to 1975. Area sources (incineration, residential, and others, including transportation), on the other hand, are expected to grow at a rate of 1.1 percent, or about 0.22 percent per year,

TABLE II-6

PITTSBURGH AND ALLEGHENY COUNTY, PENNSYLVANIA
POINT SOURCES

Definition of a "Major Point Source" = emissions of $\geq$ 25 T/yr (62 kg/day).
All units are kg/day.

	1972		1977	
Zone	CO	HC	CO	HC
1	248.5	124	248.5	124
5		2,833		2,833
9	323	162	323	162
10		944		944
14	934	467	---	---
15		945		945
16	149		149	
24		944		944
25	2,277	1,629	2,277	1,628
30		596		596
31		398		398
34	1,337	2,287	1,337	2,287
35	36,585	5,120	35,806	1,144
38		944		945
40	482	870	482	870
44	31,316	2,112	6,959	124
50	124	447	6	447
Totals:	73,775	20,822	47,587	14,391

$$\text{CO:}\quad \frac{73{,}775 - 47{,}587}{73{,}775} = 35.5\%\ \text{reduction, 1972 to 1977}$$

$$\text{HC:}\quad \frac{20{,}822 - 14{,}391}{20{,}822} = 30.9\%\ \text{reduction, 1972 to 1977}$$

over the five-year period. Other references, however, give much more sanguine estimates of future growth rates in the various categories of industrial and commercial enterprise; for example, the Implementation Plan gives growth factors for various industries ranging from 1.1 to over 7 percent. In this study an average overall growth factor of 3.5 percent per year was assumed for long-range planning purposes, effective over the period 1977-1987. The values computed for 1972 and 1977 incorporate the effects of the FMVECP and the growth incorporated in the vehicle-miles-traveled (VMT) data; this growth in VMT amounts to 1.5 percent per year for Pittsburgh and 2.8 percent for Allegheny County, between 1972 and 1977.

b. Area Sources

Point and area sources are combined in the summary tabulations given below. These data, taken from the 1972 Allegheny County Emissions Inventory (hereafter referred to as "the Inventory"), are presented in Tables II-7 and II-8 for CO and HC, respectively. A considerable difference exists between the data in the Inventory and those computed by the computer program prepared at GCA Corporation. The following comparison of the data from the 1972 Emission Inventory for Allegheny County and the output of the VEHEMI2 computer program is made for the purpose of trying to resolve the discrepancy between the emissions reported in the Inventory and those computed for the present study.

Based on the emission factor of 2000 lb CO generated for every 1000 gallons of fuel burned, the 1972 Emission Inventory prepared by the

TABLE II-7

ABSTRACT OF THE 1972 EMISSIONS INVENTORY FOR ALLEGHENY COUNTY
CARBON MONOXIDE

Motor Vehicles	Tons/yr	kg/day
Passenger cars	592,000	1,467,359
Commercial vehicles (trucks)	285,000	706,414
Buses (diesel-fueled)	2,500	6,197
Tractor-trailers	11,800	29,248
Total vehicular	891,300	2,209,218
	28,812	71,415
Total transportation	920,112	2,280,633
Total non-transport	37,659	93,343
Total, all sources	957,771	2,373,976

Vehicular sources:	93%
Non-vehicular sources:	7%
	100%

Conversion factor:

907.1846 kg = 1 ton,

366 day = 1 year (in 1972),

2.4786 ton/yr = 1 kg/day

Other Sources	Tons/yr	kg/day
RR engines	710	1,760
River boats	200	496
Aircraft	27,902	69,159
Total	28,812	71,415
Industrial Sources:		
Metallurgical	(none)	
Cement mfg.	(none)	
Asphalt plts.	(none)	
Food prod.	7	17
Printing	(none)	
Petroleum & Coal Prod.	7	17
Chemical prod.	30,000	74,359
Rubber Prod.	4	10
Stone, clay, & glass prod.	4	10
Non-ferrous metal	7	17
Metal fabrication	13	32
Gasoline industry	(none)	
Dry cleaning	(none)	
Paints & varnishes	(none)	
Total industrial	30,042	74,463
Power generating	2,336	5,790
Space Heatng.	4,628	11,471
Solid waste disposal	653	1,619
Total	7,617	18,880
Total non-vehicular	66,471 -28,812	164,758 -71,415
Total, non-transport	37,659	93,343

TABLE II-8

ABSTRACT OF THE 1972 EMISSION INVENTORY FOR ALLEGHENY COUNTY HYDROCARBONS

Motor Vehicles	Tons/yr	kg/day
Private cars	88,000	218,121
Commercial vehicles (trucks)	45,000	111,539
Buses	495	1,227
Truck-tractors	2,360	5,850
Total vehicular	135,855	336,737
	9,904	24,549
Total transportation	145,759	361,285
Total non-transport	28,574	70,825
Total, all sources	174,333	432,110

Vehicular sources: 78%

Non-vehicular sources: 22%

100%

Other Sources	tons/yr	kg/day
RR Engines	505	1,252
River boats	140	347
Aircraft	9,259	22,950
Total	9,904	24,549
Industrial Sources:		
Metallurgical	(none)	
Cement mfg.	97	240
Asphalt plants	(negligible)	---
Food Prod.	16	40
Printing	500	1,239
Petroleum & coal production	14	35
Chemical prod.	2,600	6,444
Rubber prod.	8	20
Stone, clay, & glass prod.	12	30
Non-ferrous metal	228	565
Metal fabric.	50	124
Gasoline Industry	14,170	35,122
Dry cleaning	1,700	4,214
Paints, etc.	5,855	14,512
Total industrial	25,250	62,586
Power generating	839	2,080
Space heating	2,325	5,763
Solid waste disposal	160	397
Total	3,324	8,239
Total non-vehicular	38,478	95,374
	-9,904	-24,549
Total non-transport	28,574	70,825

Allegheny County Bureau of Air Pollution Control (BAPC) gives total emissions of CO from vehicular sources (passenger cars, trucks, buses, and tractor-trailers) for the year 1972 as 891,300 tons/yr (2,209,218 kg/day). This is 3 2/3 times the output of the VEHEMI2 computer program for Allegheny County (including the city of Pittsburgh) for 1972: 603,590 kg/day. Since these two values purport to represent the same quantity, it was important for the purposes of the present study to try to resolve the apparent discrepancy.

The first thing noted was that the vehicle populations used differed by some 204,275 -- according to the Inventory there were 842,100 vehicles in the four categories of highway motor vehicles registered and operating in Allegheny County in 1971, whereas the information used in this Report gives a value of only 637,826 for the two categories they used for the year 1971 (see Table II-9). The ratio GCA/Inventory, then is 637,826/842,100 = 0.7574. For passenger cars only, the ratio for 1971 is 571714/702500 = 0.8138. Assuming the same rate of annual growth as used in the Inventory, 2.5 percent, we get an LDV population of 586,007 for 1972. The GCA/Inv ratio is 586,007/720,000 = 0.8139. The next thing that became apparent was that the average annual VMT/car numbers used in the two documents were also quite different: whereas the BAPC staff had assumed a figure of about 10,000 miles per car year (a check of their computations indicates an actual value of 9950, at 12 mi/gal average mileage), the VMT's provided by the subcontractor indicate an average annual travel of only about 8480 miles per car. This is a further proportionality factor of 0.8480. These two factors may be

TABLE II-9

MOTOR VEHICLE POPULATION FROM ALLEGHENY COUNTY 1971 & 1972 EMISSION INVENTORIES

	1970	1971	1972
Passenger cars and station wagons	682,000	702,500	720,000
Commercial vehicles (trucks) (gasoline-fueled)	97,600	99,700	102,500
Buses (diesel-fueled)	21,84	2,100	2,100
Truck tractors (diesel-fueled)	35,600	37,800	40,000
Total highway vehicles*	81/,384	842,100	864,600

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*The Emission Inventories also include motorcycles and dealer registrations, which are not included in the data furnished to us by the subcontractor. These have therefore been omitted from the above tabulation.

MOTOR VEHICLE POPULATION, FROM A.M. VOORHEES & ASSOCIATES, INC.

"In operation" as of 1 July 1971

	Passenger Cars	Trucks	Total
Allegheny County	571,714	66,112	637,826
Armstrong County	31,498	7,683	39,181
Beaver County	77,497	11,830	89,327
Butler County	51,549	12,410	63,959
Washington County	83,876	15,519	99,395
Westmoreland County	142,650	24,342	166,992
Totals for SPRPC Region:	958,784	137,896	1,096,680

checked by comparing the total VMT's: 13578293/19672131 = 0.6902; 0.8138 x 0.848 = 0.6902. Finally, the emissions index computed by the program VEHEMI3 is 40.25 gm/mi (for the LDV's only), while the emission factor of 2 lb CO/gal fuel burned is equivalent to 75.22 gm/mi, giving a factor of 0.5351. The product of these three factors is 0.3693. The ratio of emissions is, for passenger cars only, 557863/1479752 = 0.3770. (The 1,479,752 kg/day is based on the recomputed value of 597,000 tons/yr of CO instead of the 592,000 given in the Inventory.) There is thus an unexplained residual differential which amounts to only some 2.04% of the emissions ratio. Given the many imponderables and assumptions that went into these numbers, it is felt that this close a result may be considered as having accounted for the observed difference in the two sets of calculated emissions.

For the HC emissions the results are dependent upon the same three factors: of these, only the emission index and the emission factor are new: 6.68 gm/mi from the VEHEMI3 program and 11.095 gm/mi from the Inventory, respectively, giving a ratio of 0.602. The product of this value and the VMT ratio of 0.69 is 0.4156; this compares with the emissions ratio of 92556/218263, or 0.4241. The remaining difference amounts to only about 2.01 percent of the emissions ratio, a result quite close to that obtained for the CO emissions.

The other vehicle categories were not investigated in this manner, partly because of the uncertainties in the ways in which they were defined in the two documents (this report and the Inventory), and partly because the LDV category (passenger cars) is not only better defined but accounts for no less than 95.6 percent of all the VMT's for the year according to this study. Again, the situation is more complicated in the Inventory, since the trucks are handled on an average mileage basis (45 mi/day, or a total of 1.688×10^9 VMT/yr), while the diesel-fueled vehicles (buses and tractor trailers) are handled on the basis of average fuel consumption for the year with no mileage figures given. However, the VMT's for the HDV category in the present study (supposedly the group which corresponds to the "commercial vehicles" category in the Inventory) are only about 1/10th of the VMT's as calculated from the data given on page 16 of the Inventory. This large difference is only partially accounted for by the vehicle population assumptions made in the two studies: 66,112 trucks in Allegheny County as of 1 July 1971 was the basis for the figure used in our computer runs, while the Inventory gives a figure of 99,700 trucks for 1971, a ratio of 0.6631. Applying this same ratio to the 1972 estimated number of trucks from the Inventory, 102,500, we would have had a corresponding value of 67,968 trucks for our computer input value for the 1972 computations. The obvious problem here, of course, is the very large discrepancy in the average miles per truck assumed in the two instances. Whereas the Inventory study uses the figure of 45 mi/day for trucks (gasoline-fueled), the data used in this report imply a figure of only about 6.63 mi/day/truck if the HDV value of VMT is used, or 9.156 mi/day/truck if the total of HDV + OV is used. This brings to light a minor problem in the data supplied to GCA: while there are three categories of vehicles used as the basis for the VMT's, only two groups of vehicles are broken out in the vehicle population figures. Thus, another possible source of confusion and error creeps in.

The various factors and parameters used in the above discussion are included in the tables which appear below (Tables II-12 through II-16).

To sum up the stationary, or rather the non-vehicular source situation, it appears that only about 7 percent of the total CO emissions come from sources other than vehicular (defined for the purposes of this report as passenger cars, commercial trucks and tractor-trailers, and buses), while about 22 percent of the total HC emissions come from the non-vehicular sources. These figures are used in a later part of the report to derive the most probable values of emissions from non-vehicular sources in later years. A discussion of the rationale behind this procedure is perhaps superfluous in light of the paucity of data mentioned previously and the absence of any really viable alternative. Several methods of modifying these ratios were investigated; among them being the application of the ratios between the CO and HC emissions for Zone 1 for the successive years (see Table II-10) and those for the entire County, the percent reduction figures for the point sources for the 1972-1977 period, and other such derived information. After much thought and several hand calculations, it was decided to use the Inventory ratios essentially as given and to use the planned reductions of CO and HC from the major point sources as an estimate of the amounts of reduced CO and HC emissions, respectively, to be expected from non-vehicular sources over the next five years. The downward trend in industrial emissions of CO between the 1971 and 1972

TABLE II-10 (see also Figure II-12)

ESTIMATED VEHICULAR EMISSIONS FOR ALLEGHENY COUNTY (in kg/day)

Zone 1 only (computed)			Totals for all of Allegheny County (estimated)			
Calendar Year	Total CO	Total HC	Total CO	Z_1/TC (%)	Total HC	Z_1/TC (%)
1970	29844.63	4851.98	642027.11	4.6485	126139.14	3.84653
1971	28903.25	4415.93	627540.28	4.6058	114907.51	3.84303
1972	27542.52	3923.19	603589.96*	4.5631	102178.92*	3.83953
1973	25179.25	3505.03	557013.76	4.5204	91371.29	3.83603
1974	22915.87	3113.12	511777.70	4.4777	81228.85	3.83253
1975	20185.92	2656.35	455160.66	4.4349	69373.97	3.82903
1976	16704.66	2154.04	380325.58	4.3922	56306.97	3.82553
1977	13829.16	1793.87	317949.66*	4.3495	46935.10*	3.82202
1978	11339.56	1522.78	263294.33	4.3068	39878.80	3.81852
1979	9473.62	1288.19	222171.62	4.2641	33766.27	3.81502
1980	7657.86	1083.60	181409.99	4.2213	28429.60	3.81152
1981	6325.90	971.03	151388.02	4.1786	25499.60	3.80802
1982	5551.40	889.88	134224.72	4.1359	23390.69	3.80442
1983	5048.92	814.60	123348.97	4.0932	21431.65	3.80092
1984	4593.02	793.34	113393.90	4.0505	20891.55	3.79742
1985	4535.49	786.61	113169.40	4.0077	20733.44	3.79392
1986	4401.01	770.84	110996.47	3.9650	20336.53	3.79042

*Computed values - the rest of the County-wide figures are estimates.

Note 1: All percentage reductions shown are based on the 1972 value for total CO emissions for Zone 1 (27,543 kg/day). "Percent reduction" is synonymous with "rollback" in this case, since a negligible background level is assumed. These are all "no strategy" reductions; i.e., due to FMVECP only.

1972	1975	1977	1978	1979
27,543	$\frac{27{,}543-20{,}186}{27543}$	$\frac{27543-13829}{27543}$	$\frac{27543-11340}{27543}$	$\frac{27543-9474}{27543}$
	$=\frac{5357}{27543}$	$=\frac{13714}{27543}$	$=\frac{16203}{27543}$	$=\frac{18069}{27543}$
	= 26.7%	= 49.8%	= 58.8%	= 65.6% reduction

Note 2: CO and HC between them account for 91.4 to 91.8 percent of total emissions and the HC emissions are consistently 13 to 17 percent of the CO emissions in Zone 1.

Note 3: "Z_1/TC" = ratio of Zone 1 to total County emissions.

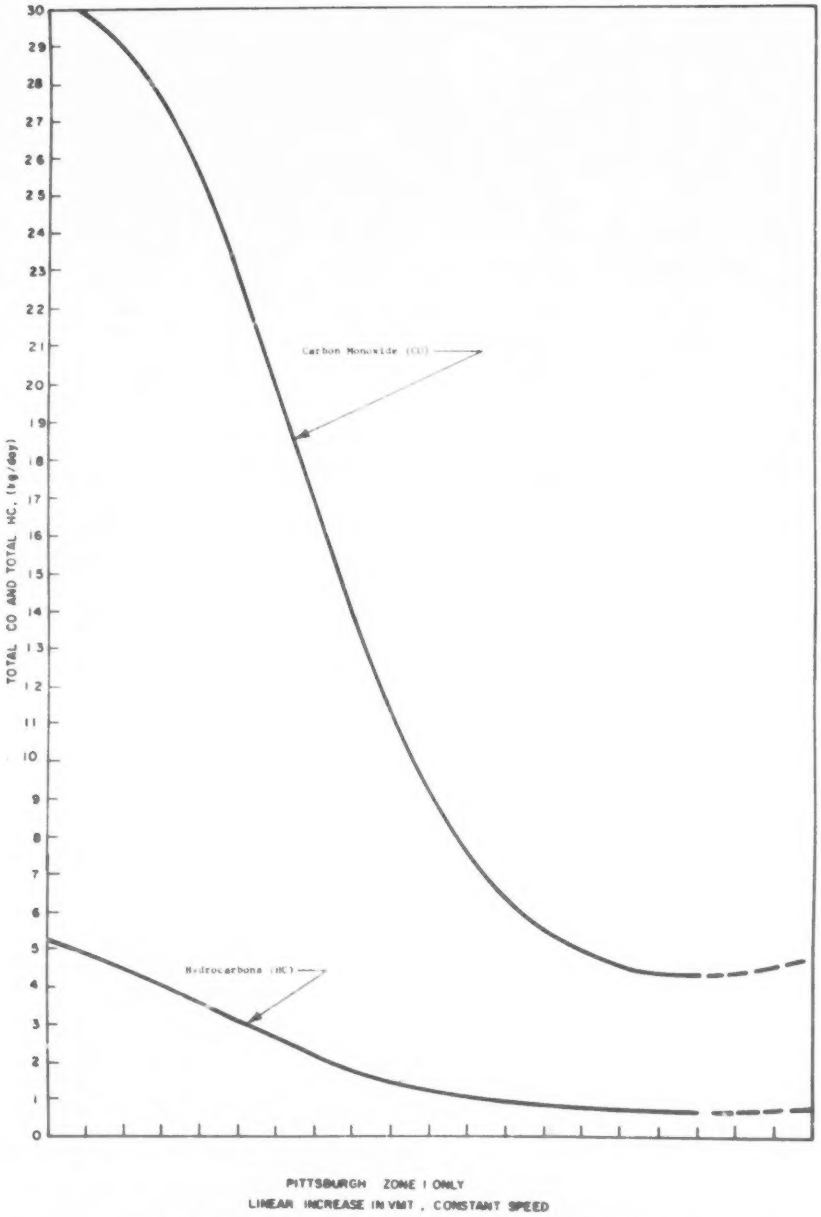

Figure II-9. FMVECP only - no strategy.

Inventories was at the rate of 6.4 percent per year, which would give a total reduction of 32 percent over the five year period. This compares well with the 35.5 percent reduction employed in the calculations summarized in Table II-18 below. There was a small increase of about 2.8 percent in HC emissions from industrial sources between the two inventories which does not bear out the three year reduction of 30.9 percent used in the HC calculations (Table II-19). The many uncertainties inherent in the planning process make any given value of predicted ambient concentrations as good as any other (within limits, of course). Thus, the forecast values of CO and HC reductions to be expected as a result of planned controls on stationary sources were used as given, with no attempt to second-guess the sources of the estimates.

As for the question of the uniformity of distribution of the various pollutants over the County, the previous discussion on the terrain features and the concentrated industrial activity in the valleys would indicate that we cannot consider the emanations from stationary sources to be sufficiently well mixed over a period of several hours to assume that we can consider point sources in the aggregate as a single area source, at least for directly vehicle-related substances such as CO. In the case of O_x, where we are concerned not so much with the immediate emanations of HC as with their photochemical products a few hours later, we must take into account the effects of wind velocity and atmospheric stability as discussed in the section on meteorology (Section II B 1 b). This, of course, is the reason for selecting a site at some distance downwind from the principal source of HC emissions; in this case, the downtown district (Zone 1). Thus, while we are completely justified in limiting our attention to Zone 1 for the CO problem, we must consider a much larger area - at least all of Allegheny County and perhaps the entire SPAQCR (nine counties) or the SPRPC region (six counties). As will be seen, we elected to concentrate our attention on Allegheny County in addressing ourselves to the problem of photochemical oxidants. This was done for two reasons: because the County has by far the greatest concentrations of gaseous pollutants of all types, including hydrocarbons, and because good information was available on a county-wide basis for emission rates of the various pollutants.

2. Assessment of the CO and O_x Problems

a. Implementation Plan Assessment

According to Pennsylvania's Implementation Plan:

> "Oxidant concentrations presently exceed the standard in the Allegheny County area. The Federal Motor Vehicle Emissions Control Program (FMVECP) and the stationary source control regulations for hydrocarbons will achieve the oxidant standard in Allegheny County by 1977."
>
> (From the Addendum to Pennsylvania's Implementation Plan - undated).

As it happens, the present study does not bear out the above statement. Based on our calculations, it appears that the transportation control strategies which must be adopted in order to bring the CO emissions down to a level where the Federal standard can be reached will, together with the planned reductions of HC emissions from non-vehicular sources, bring the total HC emissions in Allegheny County below the level at which the oxidants standard can be met. This should be accomplished by 1977, according to our calculations (see the computation sheet for HC emissions, below). The FMVECP and stationary source controls by themselves, however, will not quite do the job, falling 3 percent short of the required reduction.

Since the O_x problem is a "non-problem" as far as we can tell at this time, it remains to deal with the CO emissions rate, which does pose a definite problem, as we shall see. Having established that only Zone 1 is of concern in the case of CO emission density (Appendix C), it remains to determine the ratio of emissions to concentrations, use that to compute the so-called "safe" emission rate, and compare that with the expected "no-strategy" rate of emissions in 1977 to find the additional amount of reduction of emissions which will be required to achieve the Federal standard for ambient concentrations of CO. This procedure is developed in the following section; for now, we wish to review the analysis described in the Implementation Plan and try to determine whether it is a realistic portrayal of the CO problem in the Pittsburgh area. Here, another quote may be of value; this time, taken from the Control Strategy Evaluation, Summary, page II-1:

> "Air Quality data indicate that the carbon monoxide standard is presently being exceeded in the Allegheny County area. The Federal Motor Vehicle Emission Control Program (FMVECP) will reduce the present 8-hour maximum concentration from 24 mg/m^3

> (21 ppm) to 18 mg/m^3 (15.7 ppm) by 1975 and to less than the standard value of 10 mg/m^3 (8.7 ppm) by 1979. Since 88% of the CO emissions come from motor vehicles, stationary source control would not have a significant impact on air quality."

In this instance, as in the previous case, we cannot agree completely with the statements from the Implementation Plan. As is shown in the computation sheet for CO (Table II-A), and as was stated earlier in this report, the standard is exceeded by the maximum observed 8-hour average concentration by some 58 percent and the FMVECP will not, by itself, reduce this to the required level by 1977. Our investigation, moreover, indicates that the program will by 1975 reduce CO emissions from motor vehicles in the downtown Pittsburgh area (Zone 1) by about 26.7 percent of the 1972 value, resulting in an ambient concentration (assuming that the present emission to concentration ratio holds) of 15.5 ppm, in excellent agreement with the Implementation Plan. Furthermore, we find, as shown below, that the unassisted Federal program could not reduce the total CO emissions to a level below the standard before 1979, although it comes very close in 1978. As for the last statement, the percentage of CO emissions attributed to non-vehicular sources depends to a large extent on the manner in which these sources are defined. For example, in the Inventory we find that sources are grouped under the headings of "mobile," "industrial processes," "power generation," "domestic, industrial, and commercial space heating," and "solid waste disposal"; it turns out that "mobile" includes all forms of transportation, whereas we are concerned in the present study only with highway transport: cars, trucks and buses. This is the reason for our going to a category called "vehicular" as opposed to "non-vehicular" (i.e., all others, including other types of transport as well as the stationary sources). In a letter to Mr. Ruckelshaus dated 5 May 1972, Governor Shapp stated that "86% of the CO emissions in Allegheny County are generated by mobile sources." This is, of course, in good agreement with the figure of 88% given above for "motor vehicles". However, if we look only at the "vehicular" category as defined by GCA for this study, we find that only 7% of the total CO comes from "non-vehicular" sources (see Table II-7). But if we check the 1971 Inventory (on which the statements quoted above were presumably based), we find that no less than 96.2% of all CO emissions in 1971 came from "mobile" sources, leaving only 3.8% as the contribution from all of the stationary sources. If we try to resolve the seeming discrepancy between the Governor's statement and that of the Inventory we find that "mobile sources" in this instance apparently meant just cars and trucks -- even so, these two categories alone account for 92.4% of all the CO emitted in the County during 1971, while passenger cars alone contributed only 64.6% of the total. It is really difficult to find a combination of sources which add up to either 86% or 88% of the total emissions -- some 828,647 tons or 847,918 tons, respectively, for the year 1971. In the end, we decided to stay with the actual numbers from the Inventory as far as the ratio of vehicular to non-vehicular sources was concerned, although, as we have already seen, the absolute values could not be used.

Perhaps the most important difference between the findings of the Implementation Plan and the results of our study is that the stationary (or, as we have it, the non-vehicular) sources cannot be ignored. Difficult as it may be to derive reasonable figures for future values of emissions from these sources, we found that they must be taken into account for both CO and HC estimates if the standard is to be achieved. Realistically, one might say that if these emissions are only 7% of the total (for CO), they cannot make much difference in the final result. True enough, yet a small difference in the estimate for the year 1977 makes all the difference in the attainment of the standards for both CO and HC emissions, as is shown in Tables II-18 and II-19.

Before leaving this review of the Implementation Plan it would be well to mention a minor discrepancy which, if it were not resolved, would nevertheless have an appreciable effect on the computations of amount of "rollback" required to meet the Federal standards. I refer to the "Additions and Clarifications to Pennsylvania's Implementation Plan" dated 4 May 1972 which accompanied the letter from Governor Shapp to Mr. Ruckelshaus, cited above. In particular, it was noted that in section 51.14, Control Strategy for CO, the maximum 8-hour concentrations for CO in Allegheny County for the period November 1971-February 1972 are given as:

28 ppm	17 Nov	1700-2400
23 ppm	18 Nov	0900-1600
23 ppm	6 Dec	1700-2400
25 ppm	14 Dec	1700-2400
20 ppm	27 Dec	0900-1600
20 ppm	29 Feb	1700-2400

The raw data were carefully searched for both 1-hour and 8-hour maximum values of both CO and HC emissions; while the HC data were not available in useable form, the CO data were apparently quite accurate - at least they were consistently within "reasonable" limits. The technique for deriving the 8-hour maxima from the tabulated 1-hour high values of CO concentrations was explained earlier. Careful scrutiny of all the available data from the Downtown and Bellevue sites failed to reveal any values as high as the highest ones reported in the referenced document. The 8-hour concentrations corresponding to those reported above are:

		Downtown	Bellevue	Implementation Plan
17 Nov	1700-2400	19.8	(bad data)	28.0
18 Nov	0900-1600	18.7	" "	23.0
6 Dec	1700-2400	(hourly data not avlbl)		23.0
14 Dec	1700-2400	19.8	19.1	25.0
27 Dec	0900-1600	(hourly data not avlbl)		20.0
29 Feb	1700-2400	20.4	19.9	20.0

(All of the above data are in parts per million by volume - ppm).

It is, of course, possible that the 8-hour maxima reported in the Implementation Plan were derived from stations other than the two on which our data are based, or that data from other years are available to those who derived the information incorporated in the Plan. It was noted, however, that the figures given in the Plan for the three dates in December correspond to hourly maxima, and that the second number for the month of November corresponds to the hourly maximum for the preceding day (17 November). The first value as given in the plan could not be accounted for at all, and the last one was in agreement with our findings. While this discussion should perhaps have been included in the section on air quality data, it was felt that in our review of the Implementation Plan this was perhaps the most significant area for study since, as we have seen, there was quite good agreement in almost all other areas.

The review conducted for this Report indicates that additional information of potential value should be worked up and made available to EPA. As an example, if we examine not just the highest values for each month, but the second, third, fourth, and fifth highest, we find a significant correlation between the data for Bellevue and those for the Downtown site, with advection from the direction of Bellevue to downtown along the Ohio River valley quite apparent on some days. The significance of a quantification of this effect would be, of course, that a much better idea of the so-called "background" value of CO would be forthcoming and consequently a more accurate "rollback" number could be generated. In terms of economics this could be quite significant in that a possibly unnecessary reduction of emissions could be avoided and the cost associated with this "overkill" could be obviated. It should be emphasized that this is only a tentative finding and requires much more study and analysis before it can be accepted as factual.

CORRELATION BETWEEN OBSERVED HIGH VALUES OF 8-HOUR CO CONCENTRATION AND METEOROLOGICAL PARAMETERS OF SIGNIFICANCE IN AIR POLLUTION EPISODES

The dates and times of high 8-hour concentrations of CO in the Pittsburgh area are shown in Table II-4, page and in Appendix B. In an effort to determine the reasons for the apparent difference in the hourly data for Pittsburgh as opposed to the common experience in other locations (see discussion on page and Tables in Appendix A, also Figures II-5 and II-7, pages and , respectively), an analysis of the 1-hourly data was attempted to try to discover whether any meteorological phenomena could be found to account for this situation. No significant correlations were apparent, however. The 8-hour data were then examined in a similar manner, with the following results.

		AIR POLLUTION METEOROLOGICAL PARAMETERS					
DATE	TIME	INVERSION	TIME OF BREAK	MIXING DEPTH	AVERAGE Sfc WIND	AVG CLDS	WEATHER
18 Aug 71	03-17	Pronounced	0930	845 m.	SE-S 2.2	clr-sctd	(No Data)
1 Oct 71	05-22	Moderate	0930	750	NE-E 3.9	clr-sctd	Fog, haze, smoke
2-3 Oct 71	14-06	Weak to Moderate	1000	990	NE-SE 1.4	brkn-ovc	Ground fog, smoke, and haze
17-18 Nov 71	17-17	Moderate to Strong	1000, 1130	800	SE-SW 3.2	clr-brkn	Ground fog, smoke, and haze
14-15 Dec 71	15-05	Moderate	2000, (ND)	460	SE-S 2.9	Overcast	(No Data)
29 Feb - 1 Mar 72	15-05	Weak	1200	970	NE-S 3.4	sctd-clr	Smoke and haze
24 Feb 72 (Bellevue)	11-24	Weak	DNB	360	W-NW 3.8	Overcast	Fog (early morning)

While all of the above days contain some meteorological parameters favorable to the formation of high concentrations of air pollutants, there were other days with even stronger meteorological indications which did not display correspondingly high concentrations of CO. Conversely, some days with high average concentrations of CO did not have meteorological phenomena present which were significant in terms of air pollution. The tentative conclusion, based on a rather cursory analysis of limited data, is that no strong correlation exists between the highest observed 8-hour average concentrations and any of the commonly observed meteorological parameters.

b. Current Assessment

(1) General

This section contains a review of the methodology employed in the analysis of the existing and future situations as regards both ambient concentrations and emission rates in the Pittsburgh area, and of the results of the efforts to determine the likely situation in the target year, 1977. Also reviewed in this section are some of the more important factors involved in developing the bases for the strategy recommendations, although a review of the strategies themselves belongs to a succeeding section.

The two factors which form the basis for the development of projected values of emissions and emission densities as given in Appendix C - that is, the parameters which are varied under the control of the computer program which generates the emission values on a zone-by-zone basis, are the vehicle miles traveled (VMT) per car per year, and the mix of vehicle speeds for the highway facilities found in each zone. Repeated runs were made on the computer to assess the effect of each change in these parameters. As would be expected, the emissions varied in a linear fashion with VMT's but in a non-linear manner with speed. A partial matrix constructed of values generated during these sensitivity tests is included below as Table II-11.

To recapitulate the procedure followed in deriving the county-wide data for years other than those for which computer runs

TABLE II-11

CO EMISSIONS FOR ZONE 1 (DOWNTOWN PITTSBURGH) FOR 1977 (kg/day) Area = 1.26 sq. mi.

VMT Var. / Var. in Speeds		VMT_{77}-0	% red., Veh.em. only	% red., total em.	VMT_{77}-2.2*	% red., veh.em. only	% red., total em.	VMT_{77}-3.0*	% red., veh.em. only	% red., total em.	VMT_{77}-5.0*	% red., veh.em. only	% red., total em	VMT_{77}-7.0*	% red., veh.em. only	% red., total em.	VMT_{77}-16.3*	% red., veh.em. only	% red., total em.
		VEHICLE MILES TRAVELED PER DAY																	
SPD=0	veh.	13829	0.0											12861	7.0		11575	16.3	
	tot.	15248		0.0										14280*		6.3	12986*		14.8
SPD + [illegible]	veh.				13336	3.6													
	tot.				14735		3.2												
SPD + 2.0	veh.				13285	3.9		13205	4.5										
	tot.				14706*		3.6	14624		4.1									
SPD + 3.0	veh.										12830	7.2		12560	9.2				
	tot.										14249*		6.6	13979*		8.3			
SPD + 10.0	veh.	12654	8.5											11768	14.9		10592	23.4	
	tot.	14073*		7.7										13187*		13.5	12011*		21.2
		HC Emissions for all of Allegheny County for 1977 (kg/day) Area = 745.4 sq. mi.																	
SPD=0	veh.	46935	0.0											43642	7.0		39272	16.3	
	tot.	61229		0.0										57936*		5.4	53566*		12.5
SPD + 1.5	veh.				45473	3.1													
	tot.				59767		2.4												
SPD + 2.0	veh.				45395	3.3		45107	3.9										
	tot.				59689		2.5	59401		3.0									
SPD + 3.0	veh.										43982	6.3		43040	8.3				
	tot.										58276		4.8	57334*		6.4			
SPD + 10.0	veh.	44610	5.0											41470	11.6		37336	20.5	
	tot.	58904		3.8										55764*		8.9	51630*		15.7

*Strategy used by A.M. Voorhees Assoc. It falls 2.4 short of the goal, since 14706 -(.125)14706 = 12866 = 302 kg/day over the desired emission rate.

*These strategies meet the desired goal or better it - i.e., yield lower emission rates.

Baseline values: CO: vehicular emissions only, 1977: 13,829 kg/day, Zone 1 only. Required to meet standard: 11,145 kg/day
total emissions: 15,248 kg/day, Zone 1 only. Required to meet standard: 12,366 kg/day
HC: vehicular emissions only, 1977: 46,935 kg/day, Allegheny C. Required to meet standard: 43,939 kg/day
total emissions: 61,229 kg/day, Allegheny C. Required to meet standard: 58,233 kg/day

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were made (1972 and 1977), and in obtaining the relationships between vehicular and non-vehicular emissions, CO and HC emissions for a given area and year, and expected future values of emission reductions from non-vehicular sources, the following summary may be of assistance.

GIVEN QUANTITIES:	Source:
a. Federal standards for CO and O_x	40 CFR 50, 25 Nov 71 (p. 22385) (see also Table II-12)
b. All-source emissions, CO and HC. (NOTE: modified to be compatible with results of computer program.)	Emissions Inventory (see Section IID1 and Tables II-7 and II-8)
c. VMT's for years 1972 and 1977 (totals by zone for the SPAQCR less Fayette, Greene, and Indiana Counties); % VMT by vehicle type.	AMV Assoc., Inc. (see Appendix D)
d. SPDC & FSPD values by highway facility type for each zone of 72 zones. NOTE: SPDC = peak and off-peak speeds in mph; FSPD = fraction of total VMT to each speed class.	AMV Assoc., Inc. (see Appendix D)
e. Zonal areas (sq. mi., for each of 72 zones)	AMV Assoc., Inc. (Appendix D)
f. Age distribution of motor vehicles for each of 6 counties in SPRPC Region, 2 categories only (LDV = passenger car; HDV = truck).	AMV Assoc., Inc. (Table II-13)
g. Average annual miles driven per LDV by model year (vehicle age).	Table 14, Kircher & Armstrong
h. Average annual miles driven per HDV by model year (vehicle age).	Table 20, K & A.
i. Emission factors (gm/mi), 1975 Federal test procedure emission rates (gm/mi) by model year, deterioration factors, weighted speed adjustment factors by model year,	K & A; Table 6, Table 17, Tables 8 & 9, Figs 2 & 3 & Table B-2, Tables 15 & B-3, and Fig. 1.

	Source:
evaporative and crankcase emission rates by model year, and emission factor geographic area (Area V for Pittsburgh).	
j. Ambient concentrations of CO and O_3.	Air quality data

DERIVED QUANTITIES:

a. Partial VMT's by Zone for each vehicle type (LDV, HDV, and OV) for 1972 and 1977.	Hand computations
b. Partial VMT's by vehicle type for all years, 1970-1986 (except 1972 and 1977), Zone 1 only.	Straight-line interpolation (Table II-14)
c. Adjusted vehicle age distribution for 1/2-year adjustment (1 July to 31 December), LDV's and HDV's for Allegheny County and entire SPRPC Region.	Hand computations (Table II-15 and Figure II-10)
d. % of total vehicle population by model year (vehicle age), Allegheny County and SPRPC Region.	Hand computations (Table II-15
e. Emissions of CO and HC by vehicle type and zone.	Computer program VEHEMI2 and hand calculations (these agreed within 0.8%).
f. Emission densities by vehicle type for each zone, CO and HC.	VEHEMI2 (Appendix C)
g. Total emissions of CO and HC, by zone, for 1972 and 1977.	VEHEMI2 (Appendix C)
h. Sensitivity analyses for VMT and SPDC variations, Zone 1 only, for 1977.	VEHEMI2 (Tables II-11 and II-17)
i. CO and HC emission indices by vehicle age for calendar years 1972 & 1977, Zone 1 only.	VEHEMI3 (Appendix C)
j. Total emissions of CO and HC, 1972 and 1977, by counties (City of Pittsburgh = 20 zones, Allegheny County = 31 zones, other 5 counties = 21 zones).	Hand computations (Table II-16)

TABLE II-12

From 40 CFR 85, "New Motor Vehicles and New Motor Vehicle Engines - Control of Air Pollution," Federal Register, vol. 37, No. 221, Part II, 15 November 1972, pp. 24249-24320.

LDV	HDV
Emission standards for 1973 model year vehicles: A. Exhaust: (1) HC: 3.4 gm/VMT (2) CO: 39.0 gm/VMT (3) NO_x: 3.0 gm/VMT	HC: 275 ppm CO: 1.5% (by volume) Crankcase: 0.0
B. Evaporative: (1) HC: 2 gm/test C. Crankcase: 0.0 Emission standards for 1974 model year vehicles: (same as for 1973)	1974 model year vehicles: HC + NO_x (as NO_2): 16 gm/bhph CO : 40 gm/bhph Crankcase: 0.0
Emission standards for 1975 model year vehicles: A. Exhaust: (1) HC: 0.41 gm/VMT (2) CO: 3.4 gm/VMT (3) NO_x: 3.1 gm/VMT	OV (Diesel) 1974 model year vehicles: HC + NO_x(as NO_2): 16 gm/bhph CO : 40 gm/bhph
B. Evaporative: (1) HC: 2 gm/test C. Crankcase: 0.0 Emission standards for 1976 model year vehicles: (same as for 1975, except) A. Exhaust (1) HC: 0.41 gm/VMT (2) CO: 3.4 gm/VMT (3) NO_x: 0.40 gm/VMT	LEV (low-emission vehicle) (1) HC: 3 gm/VMT (2) CO: 28 gm/VMT (3) NO_x: 3.1 gm/VMT

TABLE II-13

COMPARISON OF PASSENGER CAR AGE DISTRIBUTION BETWEEN ALLEGHENY COUNTY AND THE SOUTHWEST PENNSYLVANIA AIR QUALITY CONTROL REGION AS OF 1 JULY 1971

Model Year	Allegheny County (incl. Pittsburgh)	% Total	SW Pennsylvania RPCR (6 Counties)	% of Total
1971	50,731	8.9	76,687	8.0
1970	78,011	13.7	121,833	12.7
1969	72,736	12.7	115,079	12.0
1968	70,052	12.2	113,417	11.8
1967	58,466	10.2	97,465	10.2
1966	63,280	11.1	108,010	11.3
1965	57,875	10.1	101,389	10.6
1964	43,353	7.6	78,010	8.1
1963	31,199	5.5	57,445	6.0
1962	19,915	3.5	37,419	3.9
1961	8,637	1.5	16,282	1.7
1960	5,678	1.0	11,401	1.2
1959	2,413	0.4	4,899	0.5
1958	1,279	0.2	2,467	0.2
1957	1,747	0.3	3,606	0.4
1956	1,302	0.2	2,641	0.3
< 1956	5,040	0.9	10,734	1.1
TOTALS:	571,714*	100.0	958,784	100.0

*This figure represents 59.6% of the passenger cars "in operation" in the SPRPC Region as of 1 July 1971.

There were also 137,896 trucks in operation in the six counties making up the Southwestern Pennsylvania RPCR as of 1 July 1971, for a total number of vehicles = 1,096,080, 87.4% passenger cars and 12.6% trucks. For Allegheny County alone, there was a marked difference in these proportions: of the 637,826 vehicles in operation there as of 1 July 1971, only 66,112 or 10.4% were trucks. These made up only 47.9% of the trucks in the entire region, showing the far greater numbers of trucks operating in rural areas in proportion to the total numbers of vehicles. It was also noted that trucks tend to be kept in service somewhat longer than cars: cars of model years 1958 and older made up only 1.8% of the total, while trucks of the same vintage made up 12.7% of their total.

A slight shift in the age distribution toward older cars is noted in the outlying areas. There are more "new" cars (<4 yrs old) in the metropolitan Pittsburgh area, and fewer "old" cars (≥ 5 yrs old), than there are in the Southwest Penn. AQCR as a whole. 1967 is the nodal year for the calendar year 1971; cars older than that are more numerous in the outlying areas, while cars newer than the 1967 model year are relatively more common in the city. Thus, for 1977, the 1973 model year would be the nodal year used.

TABLE II-14

EXTRAPOLATED "NO-STRATEGY" VMT'S FOR ZONE 1, PITTSBURGH
(mi/day)

Year	Code	LDV (.934)	HDV (.048)	OV (.018)	TOTALS
1970	13	399,772	20,545	7,704	428,021
1971	14	407,054	20,919	7,845	435,818
1972	15	414,336	21,294	7,985	443,615
1973	16	421,619	21,668	8,125	451,412
1974	17	428,901	22,042	8,266	459,209
1975	18	436,185	22,41	8,406	467,007
1976	19	443,467	22,791	8,546	474,804
1977	20	450,749	23,165	8,687	482,601
1978	21	458,032	23,539	8,827	490,398
1979	22	465,314	23,913	8,968	498,195
1980	23	472,597	24,288	9,108	505,993
1981	24	479,880	24,662	9,248	513,790
1982	25	487,162	25,036	9,389	521,587
1983	26	494,445	25,410	9,529	529,384
1984	27	501,727	25,785	9,669	537,181
1985	28	509,010	26,159	9,810	544,979
1986	39	516,293	26,533	9,950	552,776
(1987)	30	(523,575)	(26,908)	(10,090)	(560,573)

Note: The last line is not usable in the computer program VEHEMI2 as it is presently constituted.

$\Delta(\text{VMT})/\text{yr} = 7797.2 \approx 1.758\% \ (\text{VMT})_{72}$.

TABLE II-15

MOTOR VEHICLE AGE DISTRIBUTION, ALLEGHENY COUNTY AND ENTIRE SPRPC REGION
(as of 31 December 1971)

Derived for the VEHEMI2 program from figures supplied by AMV Assoc., Inc.

	Passenger Cars				Trucks			
Model Year	Allegheny County	% of total	SPRPC Region	% of total	Allegheny County	% of total	SPRPC Region	% of total
1972	18,770	3.3	28,374	3.0	2,014	3.1	3,785	2.7
1971	64,371	11.4	99,260	10.4	6,616	10.0	12,588	9.1
1970	75,374	13.3	118,456	12.4	8,141	12.3	15,732	11.4
1969	71,394	12.6	114,248	12.0	7,530	11.4	14,704	10.7
1968	64,259	11.3	105,441	11.1	6,048	9.2	12,058	8.7
1967	60,873	10.8	102,738	10.8	5,594	8.5	11,350	8.2
1966	60,578	10.7	104,700	11.0	5,310	8.0	10,791	7.8
1965	50,614	8.9	89,700	9.4	4,525	6.9	9,330	6.8
1964	37,276	6.6	67,727	7.1	3,517	5.3	7,399	5.4
1963	25,557	4.5	47,432	5.0	2,670	4.0	5,648	4.1
1962	14,276	2.5	26,851	2.8	2,103	3.2	4,514	3.3
1961	7,158	1.3	13,841	1.5	1,812	2.7	4,019	2.9
1960	4,046	0.7	8,150	0.9	1,522	2.3	3,484	2.5
1959 and earlier	11,781	2.1	24,347	2.6	8,621	13.1	22,617	16.4
Totals:	566,327	100.0	951,265	100.0	66,023	100.0	138,019	100.0
Totals, original AMV data	571,714		958,784		66,112		137,896	
% Diff.:	0.9		0.8		0.1		0.1	

The above age distributions for the two vehicle categories were created by an averaging procedure, as shown graphically in Figure II-13. The necessity for shifting the initial age curve forward in time by six months to achieve compatibility with the VMT data gives rise to a small inaccuracy, as can be seen by comparing the shape of the original distribution to that of the derived one. As shown in the table above, the differences in total vehicle population are very small -- less than 1% in every case. In light of the many other assumptions which have had to be made during the course of this study, some of which undoubtedly contribute much larger errors to the final results, and since any other approach would have required much more time and labor, this distribution was the one selected for use with the computer program which computes emissions.

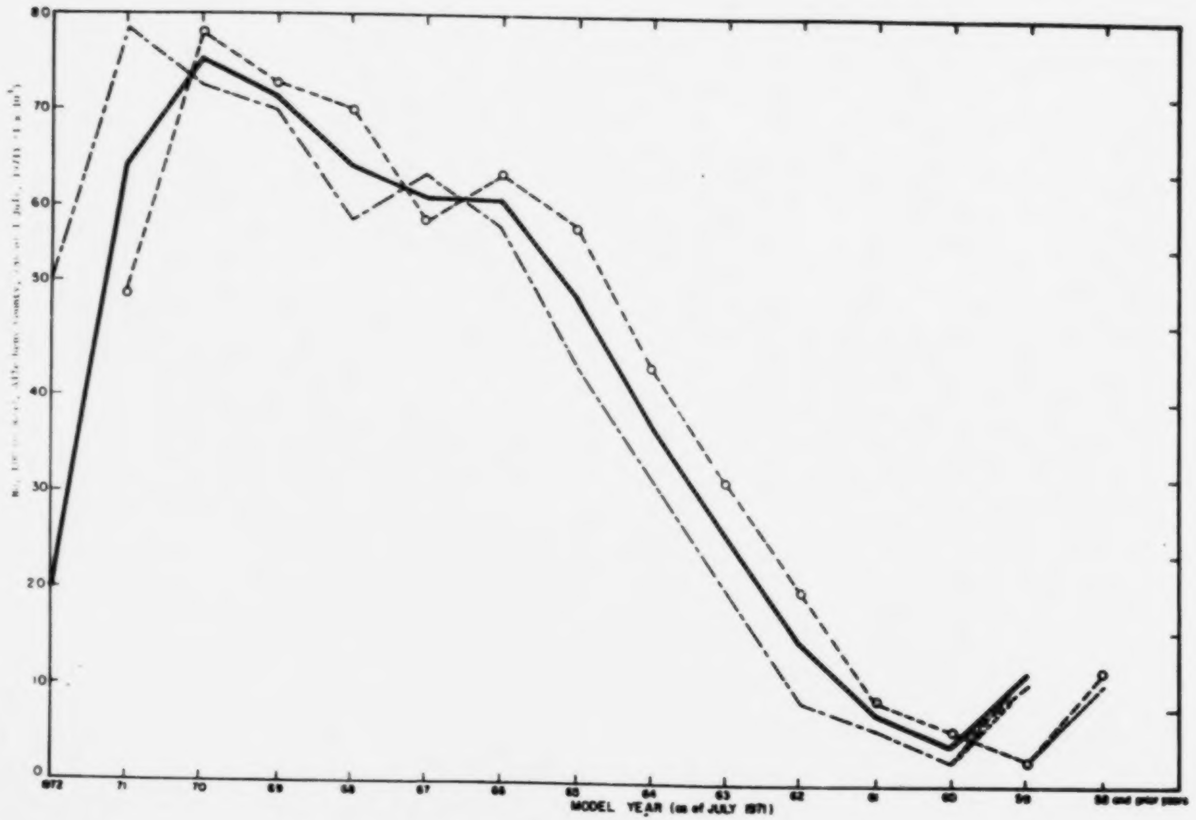

Figure II-10. Derivation of vehicle age distribution (for use with VMT data in VEHEMI2).

TABLE II-16

TOTAL VMT'S BY COUNTY FOR THE YEARS 1972 AND 1977 (mi/day)

	1972					1977				
DISTRICT #	LDV'S	HDV'S	OV'S	TOTALS	% OF TOTAL	LDV'S	HDV'S	OV'S	TOTALS	% OF TOTAL
1 City of Pittsburgh	3,458,169	177,722	66,646	3,702,537	13.4	3,713,750	190,857	71,571	3,976,178*	12.5
2 Rest of County	10,120,124	272,949	104,981	10,498,054	38.0	11,745,900	316,798	121,845	12,184,543	38.2
Allegheny County	13,578,293	450,671	171,627	14,200,591	51.4	15,459,650	507,655	193,416	16,160,721**	50.7
3 Butler County	2,086,405	34,133	12,800	2,133,338	7.7	2,398,682	39,242	14,716	2,452,640	7.7
4 Armstrong County	1,029,916	44,779	17,475	1,092,170	3.9	1,220,602	53,070	20,710	1,294,382	4.0
5 Westmoreland County	4,931,992	138,280	51,215	5,121,487	18.5	5,765,001	161,636	59,865	5,986,502	18.8
6 Washington City	3,015,601	62,049	24,820	3,102,470	11.2	3,587,162	73,810	29,524	3,690,496	11.6
7 Beaver County	1,905,955	80,675	30,253	2,016,883	7.3	2,185,843	92,522	34,696	2,313,061	7.2
TOTALS-SPRPC	26,548,162	810,587	308,190	27,666,939	100.0	30,616,940	927,935	352,927	31,897,802	100.0

* 7.4% growth = 1.48%/year
** 13.8% growth = 2.76%/year

A small redistribution of VMT's is noted between the City of Pittsburgh and the rest of Allegheny County. A slightly larger percentage of VMT's is present in the County in 1977 as compared to 1972. Similarly, there is a little more activity in the counties of Westmoreland and Washington, and a little less in Allegheny County as a whole, in 1977 as compared to 1972. Since the general idea is to get the vehicles out of the city, these small differences are in the right direction to spread the pollution around more evenly. There is ample leeway in the other zones and districts to allow for a small amount of dispersion of exhaust emissions to the outlying areas; this will not violate either the letter or the spirit of the EPA regulations directing the maintenance of existing air quality levels in those areas where the air quality is already better than the federal standards.

TABLE II-17

VMT'S USED IN SENSITIVITY TESTS

	WITHOUT STRATEGIES		WITH THE STRATEGY PACKAGES DEFINED BELOW		
	1972	1977	1977, Pkg 1	1977, Pkg 2	1977, Pkg 3
LDV:	414,336	450,749	419,196	377,276	439,883
HDV:	21,294	23,165	21,543	19,389	22,606
OV :	7,985	8,687	8,079	7,271	8,477
TOTAL:	443,615	482,601	448,818	403,936	470,966

The average "off-peak" speeds corresponding to the above VMT's, categorized by type of highway facility, are as follows (in mph):

Fwy:	39.	39.	39.	43.	40.2	40.6	39.58	39.78
Art:	19.	19.	19.	21.	19.6	19.8	19.28	19.38
Lcl:	17.	17.	17.	19.	17.5	17.7	17.26	17.34

("Fwy" = Freeway, "Art" = Arterial, "Lcl" = Local Street)

The entries in Table II-11 are the computed emissions of CO and HC in Zone 1 and Allegheny County, respectively, which would result from the application of the several strategy packages as defined below.

Package 1 consists of a 7% reduction in VMT with no change in the average speeds.

Package 2 entails a further 10% reduction of VMT from that used in pkg 1, above, for a net reduction of 16.3% from the baseline ("no-strategy") value for 1977, coupled with a 10% increase in each of the three average speed categories.

Package 3 assumes a 2.4% decrease in VMT with four different sets of speeds: increases of 3.0%, 4.0%, 1.5% and 2.0% over the baseline values of 39, 19, and 17.

The first combination was to be achieved through a program of increasing parking costs, increasing transit service, and using existing park areas for fringe parking. The second package was used only for sensitivity analysis. The third program consisted of a 12.5% rollback from the 1977 "no-strategy" emission rate attributable to an inspection and maintenance program, plus an additional 3.4% reduction in emissions due to the reduction in VMT as shown above. The increases in average speeds on the various highway facilities were presumed to arise as a result of the reduced VMT's.

(2) CO Problem

With the caveats and assumptions outlined above, we can now proceed to a discussion of the specific findings and results of our study and analysis of the air pollution situation in Pittsburgh as regards CO and O_x emissions and concentrations, both present and expected in future years.

With respect to the CO problem, the following tabulation presents the situation as of now (see Table II-18, below). The data are self-explanatory; however, a word on the assumptions and methodology employed to achieve them should be included. The vehicular emissions data come directly from the computer program VEHEMI2 (see Appendix C for a complete listing of these data). The assumptions and methodology inherent in this program have been discussed in the general introduction to this Report. The non-vehicular emissions were derived, as explained previously, by applying the 7.0% of total CO emissions due to non-vehicular sources in the Inventory to the computed value of vehicular emissions. The 35.5% reduction in non-vehicular emissions between 1972 and 1975 came from the point source data we collected during our visits to Pittsburgh. Since we had no definitive information on planned reductions beyond 1975, the same level was assumed for 1977. Beyond that year, the annual growth rate of 3.5% was assumed to take over, as far as non-vehicular emissions are concerned. The successive ambient levels of CO concentrations expected were computed using the e/c ratio (e.g., 21605/1396 = 15.5, etc.). The final result is that in order to achieve the federal standard of 9 ppm per maximum 8-hr. average by 1977, we

TABLE II-18

SUMMARY SHEET FOR PITTSBURGH
CARBON MONOXIDE

Emissions computed for Zone 1 (downtown Pittsburgh) only. Area = 1.26 sq. mi. All emission rates are in Kg/day, and all concentration levels are in ppm.

	Present (1972)	1975 (without strategies)	1977 (without strategies)	1977 (with O_x strategy only)*	1977 (with CO strategy only)
Vehicular Emissions	27,543	20,186	13,829	13,829	11,145
Non-Vehicular Emissions	2,200	1,419	1,419	1,419	1,419
Total Emissions	29,743	21,605	15,248	15,248	12,564**

e/c Ratio: 29743/21.3 = 1396.4

* No separate O_x strategy is planned - see Summary Sheet for Oxidants)

** 57.8% rollback in total emissions = 59.5% rollback in vehicular emissions required to meet federal standards.

	Present (1972)	1975	1977	1977 (with O_x)	1977 (with CO)
CO Ambient Level (maximum 8-hour average concentration)	21.3	15.5	10.9	10.9	9.0 (fed. std.)

Background CO Level — 2-4 ppm, based on emissions of known point sources in the Zone and an allowance for advection of CO from adjacent zones.

Estimates for future years (without strategies):

	1978	1979	1980	1981	1982
Vehicular Emissions	11,340	9,474	7,656	6,326	5,551
Non-Vehicular Emissions*	1,469	1,520	1,573	1,628	1,685
Total Emissions	12,809	10,994	9,229	7,954	7,236

* Assumed overall annual growth rate for industry in the Pittsburgh area = 3.5%.

	1978	1979	1980	1981	1982
CO Ambient Level (maximum 8-hour average)	9.2	7.9	6.6	5.7	5.2

Background CO Level — 2 ppm, (allowance made for some improvement in control of emissions from non-vehicular sources outside the Zone).

need to reduce the vehicular CO emissions from the present 27,543 kg/day to 11,145 kg/day; this represents a reduction ("rollback") of 59.5%. Since the federal program (the FMVECP) will achieve a reduction of 49.8% all by itself (under the assumptions outlined above), this leaves another 9.7% of the 1972 emission rate to be achieved. Another way of stating the requirement is that we need to reduce CO emissions from motor vehicles an additional 19.4% of the 1977 rate which will be achieved without any transportation strategies. Obviously, it makes a lot of difference what base year one uses in stating the percent reduction required to achieve a standard. As it turns out, it also makes a difference whether one includes emissions from other sources in his calculations of reduction required. Even though such sources contribute only 7.0% of the total CO emissions (according to our assumptions), they are not being reduced at as fast a rate as are the emissions from motor vehicles; this disparity must be compensated for by "over-correcting" the vehicular emissions, so that the actual ambient concentrations, which come from all sources, will reach the desired level.

(3) O_x Problem

The Summary Sheet for oxidants (Table II-19) is also self-explanatory. As before, the top line, vehicular emissions, comes directly from the zone-by-zone computations of the computer program VEHEMI2 which, in turn, is based on and follows exactly the procedure set forth in the paper by Kircher and Armstrong. The non-vehicular emissions are based on the ratio between vehicular and non-vehicular emissions in the 1972

TABLE II-19

SUMMARY SHEET FOR PITTSBURGH
OXIDANTS

Emissions computed for all of Allegheny County. Area = 745.4 sq. mi.

All emission rates are in kg/day, and all concentration levels are in ppm.

	Present (1972)	1975 (without	1977 strategies)	1977 (with O_x Strategy only)	1977 (with CO Strategy only)
Vehicular Emissions	102,179	69,374	46,935	(44,014)	43,034*
Non-Vehicular Emissions	28,820	19,915	14,936	(14,936)	14,936
Total Emissions	131,000	89,289	61,871	(58,950)	57,970
Percent Reduction from 1972 emission rate (tot. emissions)	0.0	31.8	52.8	(55.0) (no O_x strategy planned)	55.7
Oxidant level (max. 1-hr. average)	0.165	0.124	0.087	0.080**	< 0.080

*57.9% reduction in vehicular emissions only

**Federal standard

(amounts in parentheses are those required to just meet the federal standard)

Estimates for future years (without strategies):

	1978	1979	1980	1981	1982
▽Vehicular Emissions	39,879	33,766	28,430	25,500	23,391
▽▽Non-Vehicular Emissions	15,459	16,000	16,560	17,140	17,740
Total Emissions	55,338	49,766	44,990	42,640	41,131
Oxidant level (max. 1-hr. average)	(all levels are below the federal standard of 0.08 ppm)				

▽Assumed ratio of Zone 1 emissions to total County emissions = 3.8% (see Table II-10).

▽▽Assumed same growth factor as for CO calculations; i.e., 3.5% per year.

Emissions Inventory: according to that document, 77.9% of the total HC emissions in Allegheny County in 1972 came from sources we define in this Report as "vehicular"; thus, we have applied the same proportion to the computed HC emissions from the three categories of motor vehicles (LDV, HDV, and OV); 22.1% of the total gives the value 28,820 kg/day. Now, following the same procedure as for the CO emissions, we noted that according to the point source information given to us in Pittsburgh, a 30.9% reduction in HC emissions from these stationary sources is planned between now and 1975 (Table II-6). In the case of hydrocarbons, however, there was additional information given to us verbally to the effect that an additional 25% reduction was planned between 1975 and 1977. This gives a total reduction of 48.2% based on the 1972 emissions of 28,820 kg/day. The accuracy of the forecast figure for non-vehicular emissions is of some importance, since it turns out that, with the amount of reduction assumed, the federal program and the amount of rollback required to meet the CO standard will just meet the standard for oxidants with no special strategy required for oxidants by themselves. Based on that assumption, the numbers in parentheses show the nominal values for vehicular and total emissions which will just attain the 55% reduction in HC emissions required to meet the standard for oxidants. As can be seen, the next column of figures doesn't beat these values by very much. The oxidant problem is somewhat peculiar in that oxidants, unlike CO and hydrocarbons, are secondary pollutants, i.e., they are formed in the atmosphere as the result of an extremely complicated series of photochemical reactions which require some period of time (on the order of a few hours, ordinarily) to generate the irritating and harmful products - ozone and the other oxidizing agents - lumped together as "total oxidants". Because of the time delay implicit in the generation of oxidants resulting from photochemical reactions in the atmosphere, it is necessary to consider larger areas than are of interest in studying the CO problem. Moreover, it is not possible to measure the oxidizing agents directly under test conditions as is commonly done with CO and the other "primary" pollutants which are generated directly as a result of the combustion of gasoline in an internal combustion engine. This difficulty has been handled up to now by recognizing the close relationship between the amounts and types of hydrocarbons coming out the tail pipe and the amount of photochemical oxidants appearing somewhere downstream later on. This admittedly imperfect procedure has the advantage of being fairly straightforward computationally (the basis for the HC-O_x relationship being the curve in Appendix J of 40 CFR 51). To facilitate computation and help to insure uniformity of results, I made a tabulation of this relationship by exercising the closest possible care in reading off the values of required hydrocarbon emission control as functions of the observed photochemical oxidant concentration (maximum 1-hour average). A copy of this is attached as Table II-20. As stated in an earlier section, it was necessary to make some sort of assumption as the basis for deriving the HC emission rates for the whole of Allegheny County for the "off-years" (years other than 1972 and 1977); the one selected was that the relationship between the Zone 1 emissions and those for all of Allegheny County for the two years for which computed values were available would also hold for all the other years falling within the purview of this study. Table II-10 shows the details of this derivation.

TABLE II-20

TABLE OF VALUES OF REQUIRED HYDROCARBON EMISSION CONTROL AS A FUNCTION OF PHOTOCHEMICAL OXIDANT CONCENTRATION

(From Appendix J, 42 CFR 51, Federal Register, vol. 36, no. 228
25 November 1971, p. 22413)

Maximum Measured 1-hour Photochemical Oxidant Concentration (ppm)	Reduction in Hydrocarbon Emissions Required to Achieve National Standard for Photochemical Oxidant (%)
0.080	0
.085	4
.090	8
.095	13
.100	18
.105	22
.110	26
.115	29
.120	32
.125	35
.130	38
.135	41
.140	43
.145	46
.150	48
.155	51
.160	53
.165	55
.170	57
.175	59
.180	60
.185	62
.190	63
.195	65
.200	67
.210	69
.220	73
.230	76
.240	79
.250	82
.260	85
.270	88
.280	91
.290	95
.300	98

It should be emphasized that a constant ratio was not assumed; rather, it was assumed that the rate of change in the ratio as measured over the five year period 1972 - 1977 (i.e., 0.0035% per year, decreasing with time) was applicable to all the years 1970 - 1986. Since this assumption resulted in a function which follows closely the curve shown in Figure II-12 for the computed Zone 1 values, it was felt that this was probably the most logical course to take, given the lack of time or manpower to compute the large number of VMT's, SPD's, and FSPD's needed to compute the county-wide values more accurately (that is, directly from the computer program).

E. SUMMARY AND RATIONALE FOR SELECTION OF MODELING TECHNIQUES AND AREAS FOR AVERAGING

1. Determination of Measurements of CO and O_x

It has been determined from the measurements of CO and O_x that:

(a) The present ambient concentrations of CO and HC in Pittsburgh and Allegheny County, respectively, do exceed the federal standards to be attained by the year 1977.

(b) The amount of rollback required in each case has been determined.

(c) The federal program (FMVECP) will not, of and by itself, or in combination with the stationary source controls planned in the Pittsburgh area, achieve that amount of reduction in expected emissions.

It therefore becomes necessary to consider other measures for the reduction of emissions from vehicular sources in the Region. Following the dichotomy presented in the pertinent federal regulations with respect to sources (40 CFR 51, as amended), two types of reduction measures or strategies may be considered:

(a) Those which have their effect more or less uniformly over an entire Air Quality Control Region or a major subregion such as a county, and

(b) Those which affect directly only small, localized zones or districts.

As shown in Appendix C, we have determined, at least for the "no strategy" case, precisely which zones within the SPRPC Region make the largest contributions to the maximum concentration levels which exceed the standards. We have seen that, for reasons of economy of effort, a simple proportional or "rollback" model was used to derive the relationships between future emission rates and ambient concentrations (air quality levels). As we have also seen, the meteorological and emissions data were not of sufficient fineness of mesh to permit the use of diffusion techniques for each of the 72 zones chosen by the subcontractor to represent the Region. The subcontractor selected these zones on the bases of similarity of terrain and exposure to the prevailing meteorological elements, population and traffic density, and type of highway facilities present within each zone. Our review disclosed no reason to change any of the zone selections made by the subcontractor (see maps, Figures II-2 and II-3).

Since the downtown Pittsburgh district (Zone 1) was the only area where CO emissions constituted a serious problem, the method chosen was to establish the present ratio of emissions to concentration (e/c ratio), then, using that as the relationship between emissions and expected ambient concentrations in future years, to calculate the amount of rollback required to meet the federal standard by 1977. This, in turn, led to the determination of the "safe" emission rate from all sources of CO which would, assuming the 1972 e/c ratio was valid for 1977, result in the desired level of concentration of CO in Zone 1.

In the case of the oxidants problem, the area chosen was all of Allegheny County. The basic reason for this selection has already been given: the physical and chemical nature of generation of photochemical oxidants is such that the immediate, direct, localized emanations from the tailpipe are not of paramount concern; rather, it is the secondary contaminants arising from the complex photochemical reactions occurring in the atmosphere over an appreciable period of time (several hours) that is the problem in this case. Since the ambient air in which these pollutants are being generated is moving itself under the influence of meteorological elements as discussed above, a much larger region is required for study and evaluation. As stated above, the ideal positioning for an oxidant-measuring site is some three to five hours (5 to 15 miles) downwind of the principal source of HC emanations (usually the downtown area, as in this case). We have seen that, partly due to fortuitous circumstances, the site from which the measurements of ozone were made during the summer of 1971 in Pittsburgh was very well suited to its purpose. As with CO, albeit on a much larger geographical scale, the single sampling site was deemed adequate for the present purpose since it represents the greatest ambient concentration to be expected within the entire SPRPC Region. The three additional counties which, with the six counties making up the SPRPC Region, compose the SPAQCR, were surveyed briefly in the early stages of the present study. The conclusion reached was that, while there are a few point sources, some of considerable magnitude, located within these counties (e.g., the large power plant near Indiana, Pennsylvania), the ambient concentrations of CO and HC at no point approach critical levels affecting any appreciable population groups. The terrain, meteorology, and population and vehicle densities are similar to those in the adjacent counties included within the SPRPC Region (Washington, Westmoreland, and Armstrong, respectively) and further study of these three counties was deemed both unnecessary and inappropriate in view of the terms of the present contract which is couched in terms of cities rather than AQCR's.

It was apparent that the observed concentrations of CO do not follow the distributions in space and time commonly observed elsewhere; i.e., for CO, the greatest 8-hour concentrations elsewhere usually tend to be grouped in the evening or nighttime hours during periods of limited atmospheric dispersion (low mixing, or high stability conditions), typically during the fall and winter months, while, as we have seen, the situation in Pittsburgh seems to be quite different. The highest O_x concentrations tend to occur in the late morning or early afternoon during the season of greatest insolation (June, July and August, usually), following high emanations of HC during the early morning hours. The fact that this disparity between the time of maximum expected concentrations of CO and O_x exists dictates that certain strategies will be more effective in reducing one of the two pollutants than they will be on the other; indeed, it is possible that some measures taken to alleviate, say, the CO problem could actually exacerbate the O_x situation, or vice versa. This constitutes an additional constraint on the choice of strategies, whether applied to a small neighborhood, an area as large as a traffic analysis zone or one of our larger air pollution analysis zones, a whole county, or the entire SPRPC Region. Given the amount and kinds of meteorological and air quality data available to us at this time, the terrain and vehicle density in the various portions of the Region, and the physical nature of the two pollutants studied in this Report, it is felt that the methodology and area sizes selected are optimum for the present purposes.

Two important things to keep in mind are: (1) it is the VMT's (vehicle miles traveled), not the number of cars, that are of importance in the above discussion; (2) it is not the absolute tonnage of CO or HC emissions that is important in making comparisons between, say, the Allegheny County BAPC's emission figures and those generated from the SPRPC's VMT figures, but rather the ratios between vehicular and non-vehicular emissions, between successive yearly emission data, between CO and HC emission rates, and so on. As long as we are consistent in our choice of baseline figures, we are interested at this stage primarily in determining the percentage reduction required (the "rollback") rather than the absolute values of the tons per year or kilograms per day of CO, HC, or any other pollutant. As has been repeatedly pointed out, we do need much better information on the actual amounts of the various pollutants being introduced into Pittsburgh's air. To meet the 15 February 1973 deadline imposed by Federal law, however, the ratios, not the absolute values, are what is needed, and these have been pretty well determined.

2. Conclusions

As far as the extent and severity of the CO and O_x problem is concerned, it may be stated in summing up this part of the Report that there is a definite CO problem, that some sort of transportation strategy will be required to meet the Federal standards by the target date, and that if this is done, no separate oxidant problem will exist in Allegheny County by the year 1977; i.e., the Federal standards for photochemical oxidants should be met.

III. IDENTIFICATION AND EVALUATION OF TRANSPORTATION CONTROL STRATEGIES

A. STRATEGY EVALUATION METHODOLOGY

This process describes the process used to evaluate the various alternative strategies for the reduction of emissions.

The general methodology used in the evaluation of the alternative strategies is illustrated in Figure III-1. As indicated on this figure, the major steps in the process are:

- Generate Alternatives — A listing of all alternative strategies to be considered, regardless of any constraints.
- Preliminary Screening — Certain alternatives appearing to be immediately infeasible are eliminated from further consideration.
- Impact Evaluation — This set of rankings is the basis for the selection of a recommended control strategy. Major elements of the evaluation process are:
  (1) Technical Effectiveness: Each alternative measure is examined to determine the extent to which it is effective in eliminating emissions.
  (2) Economic Cost: This state of the analysis assesses the cost of the various emission reduction measures in "traditional" economic terms.

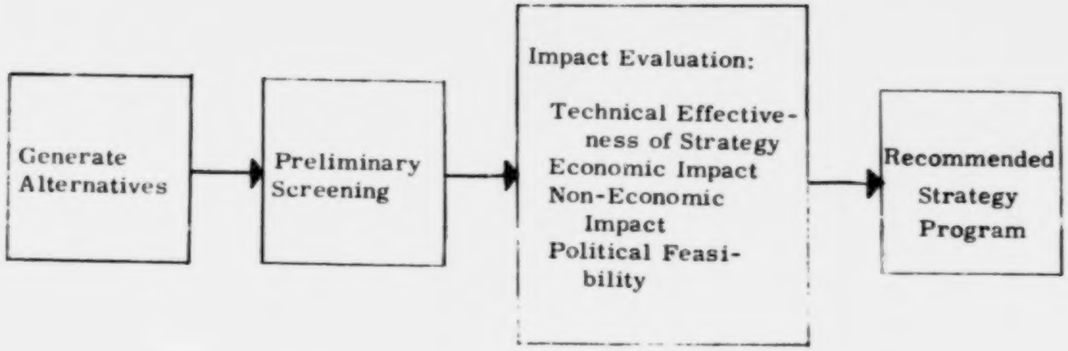

Figure III-1. Development of Recommended Control Strategy Program.

(3) Non-Economic Cost: In addition to economic costs, various other impacts of the alternative emission control strategies are considered. These impacts include social, administrative, legal and technical impact.

(4) Political Feasibility: The political feasibility of the various strategies is also examined as a separate impact.

- Recommended Program — based on the results of evaluation matrix, a recommended program of control strategies was developed.

B. GENERATE ALTERNATIVES

A basic list of all candidate strategies was compiled and classified according to the manner in which the strategies contributed to the objective of reducing emissions. This list is presented below:

Reduce Emission Rate

- Traffic Flow Improvements
    - Upgrade Existing Streets
    - Loading Zone
    - Metering
    - Information Systems
- Source Control
    - Retrofit
    - Inspection
    - Fuel Conversions
    - Idling Controls

Reduce Vehicle Miles of Travel

- Reduce Travel Demand
  - Four-Day Week
  - Communications Substitute for Travel
  - Episode Specific Controls
  - Traffic Flow Restrictions
  - Motor Vehicle Use Restraint
- Increase Transit Use
  - Short-term Transit Improvements
  - Long-term Transit Improvements
  - Transit Fares
  - Tolls
  - Parking Taxes and Charges
  - Parking Restrictions, Modification of Supply
  - Vehicle-free Zones
  - Reserved Bus Lanes
  - Increase Fuel Tax
  - Episode Specific Controls
- Increase Occupancy
  - Car Pools
  - Tolls
  - Metering
  - Episode Specific Controls
  - Vehicle-free Zones
  - Parking Taxes and Charges
- Shift Travel Patterns
  - Staggered Hours
  - Fringe Parking
  - Night Goods Delivery
  - Location of Government Offices
  - Zoning and Parking
  - Through-traffic Bypass

C. PRELIMINARY SCREENING

A preliminary screening of the preceding list indicated several alternatives that appear to be immediately infeasible. The following alternatives fell into this category, and were eliminated from further considerations.

1. Idling Controls

On the basis of current information, it has not been established that this strategy yields sufficient emission reductions to justify the serious enforcement problems its use would necessitate.

2. Communications Substitutes for Travel

The long range outlook for such technology indicates that considerable amounts of personal travel will be replaced by communications (without travel). However, the point where this will result in measurable decreases in VMT is beyond the time frame of this analysis.

3. Episode Specific Controls

Despite considerable local interest in this measure, it was held to be inappropriate at this time for the attainment of the desired 1977 emissions rollback objectives. As more precise information is developed concerning the frequency with which air quality standards are exceeded, the effectiveness of episode specific controls should be re-evaluated.

4. Motor Vehicle Use Restraint and Traffic Flow Restrictions

The experience in various cities where motor vehicle use restraints have been employed indicated that such restraints are feasible only if a number of conditions are met. A major prerequisite for a successful vehicle-free zone is the provision of transit service at a level which furnishes an attractive alternative to the use of the private automobile. Another important precondition for the success of vehicle-free zones appears to be enthusiasm on the part of employers, employees, institutions and commercial establishments in the affected areas. An additional apparent prerequisite of success for vehicle-free zones is the undertaking of comprehensive planning by the responsible jurisdiction, and the support of downtown merchants.

None of these conditions appears to be met at present in the Pittsburgh area, and it is highly unlikely that this climate will alter significantly before 1977. It is not likely that transit service will be improved to a level such that it could be considered an attractive alternative to automobile use by 1977. It should be noted that this does not imply that no transit improvements and related increases in ridership will be obtained; it is implied, however, that improvements sufficient to permit the implementation of vehicle-free zones will not be forthcoming. Furthermore, there is no reason to believe that employers, employees, institutions and the business community will accept major vehicle restraints. Within the last decade, the CBD area has enjoyed a very substantial increase in office floor area and employment. CBD retail activity has not only held its own, but has actually expanded in the past few years. Both the gains in employment and retail activity have taken place simultaneously with increases in the percentage of trips to the CBD by automobile. Given the lack of attractive transit alternatives, it does not appear reasonable that CBD employers, employees and retail interests would accept the major de-emphasis of automobile trips that is implied by the institution of vehicle-free zones. Incidents such as the recent parking strike, which involuntarily created a vehicle-free zone in the entire Triangle, reinforced much of the downtown community's wariness of this approach.

5. Long-term Transit Improvements

It does not now appear that any rapid transit system or segment thereof will be operational by 1977. Even if the legal status of the now-stalled Early Action transit program was clarified, and implementation of this plan started immediately, it is not expected that the rapid transit mileage stipulated in this plan would be operational by 1977. It is furthermore likely that the legal resolution of the Early Action plan will require considerable more time, thus delaying even further the implementation of any major transit improvements therein. It seems safe, therefore, to assume that implementation, if any, of these plans will be delayed to well beyond 1977.

6. Bypass for Through-traffic

Litigation involving many aspects of the freeway and expressway system in the near vicinity of the Triangle is increasing the likelihood that these improvements will not be operational by 1977. Furthermore, it is almost certain that no facility, as yet unplanned, will contribute substantially to the reduction of through-traffic in the Triangle by 1977. It furthermore does not appear to be reasonable to expect that substantial alleviation of through-traffic in the Triangle can be accomplished by further utilization of existing surface streets, since this alternative has undoubtedly been exhausted over the years of traffic increase in the Triangle.

D. IMPACT EVALUATION

This stage of the analysis is the heart of the evaluation process. In this evaluation, the total impact of the various control alternatives is broken up into a spectrum of sub-impacts. Criteria relevant to each of these sub-impacts are derived and applied. Based on the application of such criteria, an overall ranking of the alternatives is developed.

The following sections describe the major elements in the evaluation procedure.

1. Technical Effectiveness

Table III-1 ranks each control strategy from one through five in each of three categories. The three categories are: 1) effective reduction of the rate of emissions in grams per vehicle mile; 2) effective reduction of vehicle miles of travel (VMT) in the analysis area; and 3) effective geographical or temporal shift of vehicle miles of travel for the area analyzed.

The rankings for each criteria are relative, and the degree of effectiveness increases to a maximum value of 5. Least effective strategies would have a ranking of 1. The final ranking of each control strategy represents effectiveness in reducing emissions. A final ranking of 1 represents an expected reduction of VMT or emissions between 0 and 1 percent. Final rankings 2 through 5 represent 1-4 percent, 5-8 percent, 9-19 percent, and 20-100 percent expected VMT or emission reductions, respectively.

TABLE III-1. RATING OF ALTERNATIVE STRATEGIES TECHNICAL EFFECTIVENESS

Strategy	Rating*			
	Emission Red'n	VMT Red'n	Travel Shift	Total
Reduce Emission Rate				
Traffic Flow Improvements				
Upgrade Existing Streets	2	1	1	2
Loading Zone	1	1	1	1
Metering	2	2	2	3
Information Systems	1	1	1	1
Source Control				
Retrofit	4	1	1	3
Inspection	4	1	1	4
Fuel Conversion	2	1	1	2
Reduce Vehicle Miles of Travel				
Reduce Travel Demand				
Four Day Week	2	2	2	2
Increase Transit Use				
Short Term Transit Impv.	2	2	1	2
Transit Fares	2	3	2	3
Tolls	2	3	2	4
Parking Taxes and Charges	2	3	1	3
Parking Restrictions	2	1	1	2
Vehicle-Free Zone	5	5	5	5
Reserved Bus Lanes	2	2	1	2
Increase Fuel Tax	1	2	1	2
Increase Occupancy				
Car Pools	1	1	1	1
Tolls	**	**	**	**
Metering	**	**	**	**
Vehicle-Free Zones	**	**	**	**
Parking Taxes and Charges	**	**	**	**
Shift Travel Patterns				
Staggered Hours	2	1	1	2
Fringe Parking	2	2	2	2
Night Goods Deliveries	2	2	2	2
Government Offices	1	2	2	2
Zoning	2	2	2	2

* Ratings based on findings in this section.

** Strategy rated previously in this table.

The evaluation of each strategy was based upon the probable and reasonable degree of implementation that could be accomplished by 1977 without major expenditures of capital. For particular control strategies, the effectiveness of reducing emissions is very sensitive to the degree to which the strategy is implemented. Therefore, the rankings for those control strategies are not rigid, e.g., increasing parking costs in the CBD by 50 cents per day would be less effective in reducing emissions than a $1.50 increase.

It should be noted that the estimated VMT and emission reductions are applicable on a zonal basis. Retrofit, increased fuel tax, and inspection and maintenance estimated reductions are the only figures that are applicable on a regional basis. All other control strategy reductions are geographically and temporally specific. In particular, the control strategies were predominantly analyzed with respect to the CBD. In order to reduce emissions on a regional basis by more than 5 percent by 1977, retrofit and inspection and maintenance programs should be pursued.

Presently, it is known that approximately 50 percent of the vehicle trips in Zone 1 are local trips.[51] Local trips are defined as trips which begin or end or begin and end in the zone being analyzed. The remaining trips which travel in Zone 1 are defined as through trips. It is estimated that in 1972, 50 percent of the vehicle miles travelled in Zone 1 are generated by local trips. In 1977, there are 241,600 projected auto person trip ends in Zone 1. Since this is approximately the same number of trip ends as exists in 1972, the VMT growth from 1972 to

1977 is expected to be caused by through trips. Under this assumption, 45 percent of total travel in Zone 1 in 1977 will be generated by local trips.[52] In 1977, it is projected that there will be a total of 193,000 transit attractions with 30 percent of this total being choice transit users and the remaining 70 percent being captive users. These projections are used in the following analyses when local and overall reductions are estimated. The following sections describe each strategy.

a. Retrofit

Assuming the same age mix of operating cars that existed in 1971 for the Southwestern Pennsylvania region would exist in 1977 gives:

5.4 percent of all operating cars would be pre-1968 models
39.9 percent of all operating cars would be 1968-1972 models
22.0 percent of all operating cars would be 1973-1974 models
61.9 percent of all operating cars would be 1968-1974 models
32.7 percent of all operating cars would be 1975-1977 models

Appendix F shows the contribution of total vehicle miles of travel by each model year.*

The following references to emission rate reductions apply to gas powered light duty motor vehicles except motorcycles. In estimating emission reductions for the region for 1977, the preceding age mix was assumed and gas powered light duty vehicles were estimated to generate 96 percent of the vehicle travel in the region.

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*See Appendix F for the source of the age mix and vehicle miles of travel by model year.

It is estimated that retrofit of pre-1968 vehicles (pre-controlled vehicles) could reduce their emission rate by 12-68 percent for hydrocarbons, 9-63 percent for carbon monoxide, and 0-48 percent for nitrogen oxides, depending on the the retrofit device used. This rate reduction would reduce emissions for the region in 1977 by approximately 0.28-1.56 percent for hydrocarbons, 0.2-1.45 percent for carbon monoxide, and 0-1.10 percent for nitrogen oxides.* For controlled vehicles with model years between 1968 and 1972, exhaust gas recirculation could reduce the nitrogen oxide emission rate by 40 percent, which would reduce the amount of nitrogen oxide emissions for the region by 14.7 percent. For controlled vehicles with model years between 1968 and 1974, an oxidizing catalytic converter could reduce the emission rate of carbon monoxide and hydrocarbons by 50 percent, which would result in a 31.5 percent reduction of carbon monoxide and hydrocarbon emissions for the region.[53] If the most effective retrofit devices were implemented, the 1977 regional emission reductions would be 33.1 percent for hydrocarbons, 33.0 percent for carbon monoxide, and 15.8 percent for nitrogen oxides. If one-fourth of the maximum reductions were achieved due to cost, deterioration, or quality control, then the estimated reductions would be 8.3 percent for carbon monoxide and hydrocarbons and 4.0 percent for nitrogen oxides.

b. Inspection and Maintenance

The implementation of an inspection and maintenance program using a loaded emissions test has been estimated to reduce initial emissions 25 percent for hydrocarbons, 19 percent for carbon monoxide and

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*See Appendix F.

0 percent for nitrogen oxide. Assuming twelve month periods between checks and a linear deterioration rate will result in an average of 12 percent reduction in the rate of emission for hydrocarbon and 10 percent and 0 percent reductions for carbon monoxide and nitrogen oxides, respectively.[54] These average reductions in the rate of emission for each pollutant are applicable to gas powered light duty motor vehicles, and since these vehicles generate approximately 96 percent of all vehicle travel in the region, emission reductions would be slightly less than the rate reductions.

c. Fuel Conversion

Gaseous fuel conversion from gasoline to liquified petroleum gas, compressed natural gas, or liquified natural gas could reduce the emission rate of carbon monoxide significantly for light duty vehicles which do not meet the stringent Federal standards in 1975. Although the magnitude of reduction is significant, three constraints reduce the effectiveness of this control strategy. The first constraint is the limited supply of natural gas or petroleum gas. As long as new deposits of these fuels are not discovered, the conversion to these fuels will be limited. The second constraint is the possible prohibition of vehicles using or transporting these gaseous fuels through tunnels and on bridges. The last constraint is the problem of distributing the fuel to consumers. For these reasons, the probable use of this control strategy would be confined to fleets of vehicles. The reduction in regional emissions by 1977 would not be substantial; however, the reduction of emissions in small areas such as a CBD, could be significant.

It has been estimated that in Manhattan, the conversion of fleet taxis could reduce the emission rate of carbon monoxide by 85.3 percent initially.[55] In Pittsburgh's CBD, approximately 5 percent of the vehicle trip ends are generated by taxis. Since local travel is approximately half of the total travel in the CBD, the travel generated by taxis is approximately 2.5 percent of the total travel. Based on the assumptions above, the conversion of taxis in the CBD of Pittsburgh could reduce carbon monoxide emissions by 2.1 percent daily. In order for this plan to work properly, it is assumed that these converted taxis would be able to use the tunnel that must be traveled when going to the Greater Pittsburgh Airport from the CBD.

d. Upgrading the Existing Streets

The upgrading of the existing street system by decreasing delay time and increasing agerage vehicle speed by improving the signal system and the physical characteristics of roadways and intersections would decrease emissions per vehicle mile for carbon monoxide and hydrocarbons. These improvements generally come under TOPICS programs. Figure III-2 depicts the expected percent decrease in carbon monoxide and hydrocarbons emission rates expected for average speed increases between 15 and 30 miles per hour.

In the core area of Pittsburgh, average speed increases of 10 percent on the street system affected by TOPICS could be realized during the peak 12 hour period. The TOPICS program could have an effect

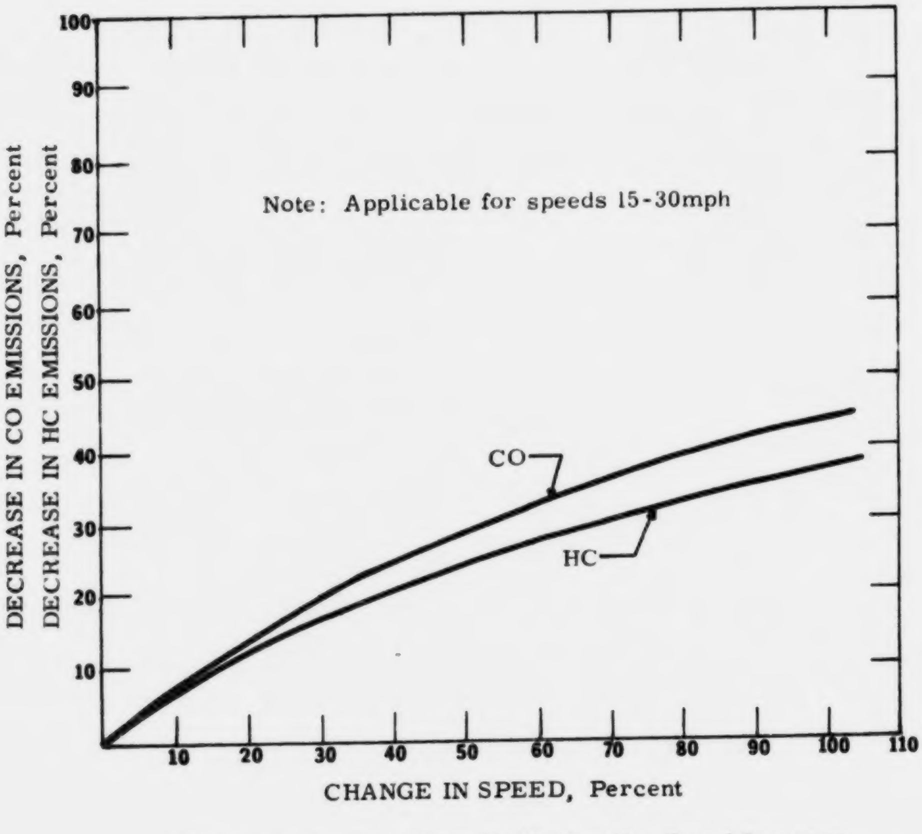

Figure III-2. Emissions Reduction Vs. Speed Increase

on approximately 20 percent of vehicle travel during the peak 12 hour period, and thus would have an overall effect of increasing speed by 2.0 percent.

Based on these assumptions and Figure III-2, the rate of carbon monoxide emissions and hydrocarbon emissions during the 12 hour period would decrease by approximately 1.5 percent. For a daily period, carbon monoxide and hydrocarbon emissions would decrease approximately 1.0 percent. During a short time period, the increase in speed on facilities is not liable to attract more users. If this did occur, then the decrease in emissions due to speed increases may be offset.

e. Loading Zones

The major advantages of controlling commercial use of on-street loading zones are to increase capacity of the street and to increase speed. Emission rate reductions can be estimated using Figure III-2 after an estimated speed increase is determined. Capacity increases can be estimated through standard highway capacity analysis. Although increasing capacity is usually desirable in traffic engineering, it would be undesirable in reducing total emissions for a particular area. The impact of this control strategy would also be limited in that the controls would be applied to particular facilities and in most conditions would affect a small percentage of the total problem. The expected reduction in emissions for Pittsburgh s CBD would be less than 1 percent due to improved controlling of loading zones.

f. Metering

The reduction in emission rates due to freeway metering is treated in a manner similar to the previous control strategy. A major improvement would be the increase in average speed by controlling the density of traffic on the facility. This strategy, if instituted, could be used to strictly control the volume of traffic on the facility and consequently stabilize or reduce vehicle miles of travel. If it is used for this purpose, alternative transportation facilities such as a viable transit alternative must be available. Closing an exit ramp to a CBD to private automobiles while allowing buses to freely use it is a strong example of metering traffic. The effect in the reduction rate of emissions can be measured by using Figure III-2, and by estimating an average speed increase. The reduction due to effective metering could range from 5 to 8 percent.

g. Information Systems

This strategy is similar to all traffic flow improvement strategies in that one goal of the strategy is to increase average speed for a portion of the auto users. By doing so, Figure III-2 could be used. In order to reduce the rate of emissions by 5 percent or more, the average speed for the entire day for all vehicles in the area must be increased by 5 percent or more. It is estimated that a 1 percent decrease in emissions using this control strategy is maximum for most systems.

h. Four Day Week

The maximum reduction in work trips per day that could be expected due to the institution of the four day week is 43 percent. This assumes the reduction of present work trips from ten trips per week to eight trips per week spread equally over seven days a week. A more reasonable maximum reduction in daily work trips is 20 percent, based on spreading the eight trips equally over five days.[56] An additional benefit realized by reducing work trips is increased average speeds. It is estimated that decreasing work trips by 20 percent during the peak period (assuming auto occupancy and modal split remain constant), would increase average speed by approximately 20 percent on facilities which were carrying volumes near capacity during the peak period. This would reduce carbon monoxide and hydrocarbon rates of emissions by approximately 12 to 15 percent. Since work trips comprise approximately one-third of all trips for the region, they contribute at least 33 percent of the vehicle miles of travel. Therefore, a 20 percent reduction of work trips per day would reduce vehicle miles of travel by approximately 6.6 percent. The emission reduction due to increased speeds would contribute another 0.12 x 0.20 = 2.4 percent (the 0.20 represents the percent of trips occurring during the peak periods). Thus, a 20 percent reduction in work trips per day would cause an approximate 9 percent decrease in emissions.

Since Pittsburgh's CBD experiences a greater percentage of work trips than the regional average, emissions produced by local vehicle trips would be reduced by approximately 12 percent. It should be noted here that overall auto occupancy and modal split may decrease but losses should be relatively small, especially for modal split where a majority of transit useres are captives. Even if all workers went to a four day week by 1977, the resulting reduction in emissions anticipated on particular days could be insignificant if the scheduled days off were not spread equally. For example, if all employees were on a four day week, and half were off on Mondays and half on Fridays, the implication would be that work trips would be halved on Mondays and Fridays, and no reduction in emissions would result on Tuesdays, Wednesdays and Thursdays. If the meteorological conditions were unfavorable on a Tuesday, Wednesday, or Thursday, then the control strategy would not be of any help. Switching to a four day week would reduce emissions on particular days, but proper scheduling of the individual's day off is crucial in reducing emissions for all days. Since meteorological conditions are random, the optimal use of the strategy is to spread the reduction equally over all days. Assuming that 25 percent of the CBD work force is on a four day week, and assuming optimal scheduling, the resultant decrease in total emissions would be 1.5 percent. In Pittsburgh's CBD, approximately 15 percent of the workers are government employees. If these workers were on a four day week by 1977, and optimal scheduling were implemented, an overall emission reduction of 0.9 percent would result.

i. Short Term Transit Improvements

The basic short term improvement that can be accomplished is the reduction of transit travel time. The modal split model developed by SPRPC for the region is divided into two parts. The first part estimates captive transit users. The travel time was not found to appreciably affect captive modal split. For this reason, short term transit improvements measured in transit travel time reduction were not assumed to affect captive modal split. The second part of the model estimates choice transit usage, which was found to be sensitive to transit travel time reduction. The estimation of choice transit usage was further divided into two equations.

The first equation estimates choice transit usage for those trips made exclusively on buses in mixed traffic. In this case, modal split varies inversely with the excess travel time ratio. As can be seen in Figure III-3, the excess travel time ratio does not affect choice modal split unless the ratio is less than 0.5. This ratio is difficult to achieve during a short time period. The transit system headways would need to be decreased significantly, transfers would have to be reduced, and coverage would have to be extended so as to practically provide door-to-door service.

For example, let's assume a user's trip takes 40 minutes by transit and 25 minutes by automobile. Furthermore, assume the transit trip time is comprised of 6 minutes walking, 6 minutes waiting, one transfer which is penalized 9 minutes and 19 minutes running time. Let the highway trip be comprised of 10 minutes terminal time and 15 minutes running time. Then the existing excess time ratio is $(6 + 6 + 9)/10 = 2.1$. In order to have a significant increase in usage, the excess transit time must be

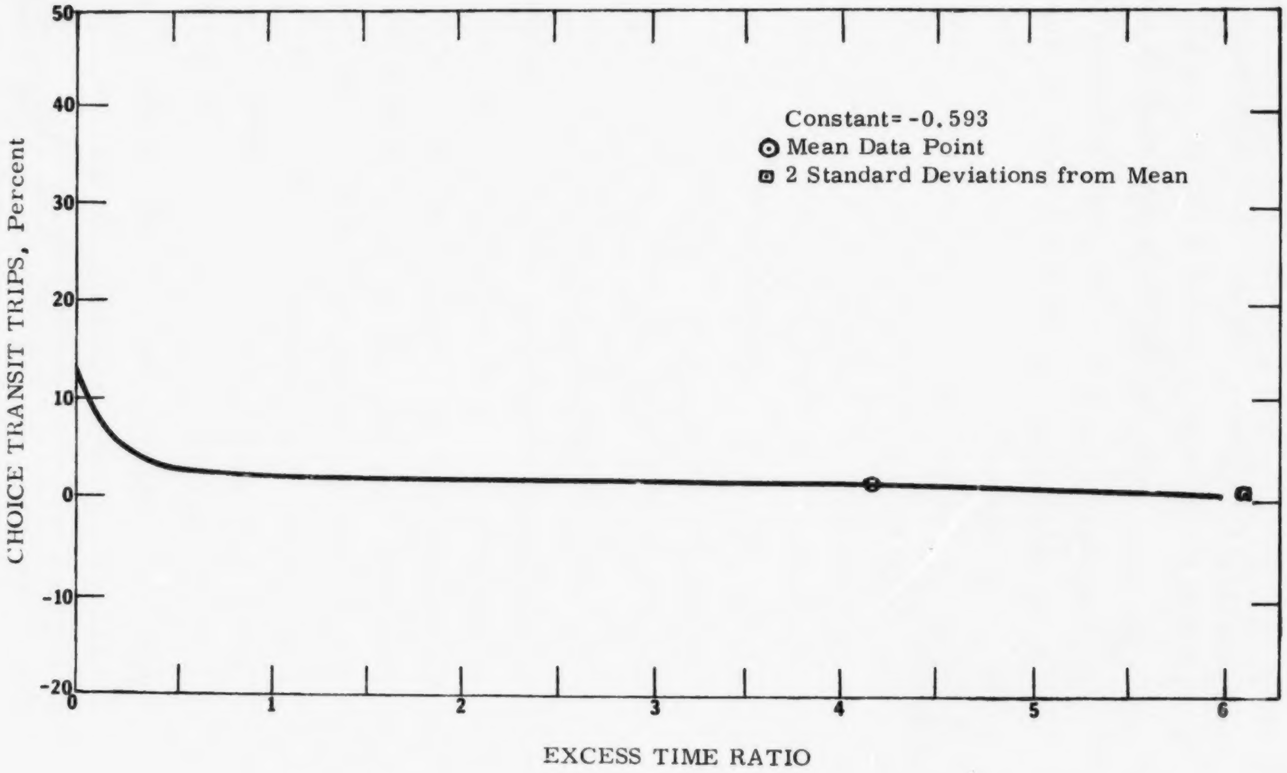

Figure III-3. Percent Choice Bus Transit Trips Sensitivity Analysis

reduced from 21 minutes to 5 minutes. To do this, the transfer must be eliminated so that excess time would now be 21 - 9 = 12 minutes. If the waiting time is reduced by half to 3 minutes, then the headways on the bus routes must be halved also. This means doubling the number of buses which are servicing the area. This would now bring the excess time to 12 - 3 = 9 minutes. To reduce the excess time to 5 minutes for transit, the bus stop must be moved 4 minutes closer to the user's home. Since the original total walking time was 6 minutes (0.1 hour), the approximate total distance the user walked was 0.1 hr x 3 mph = 0.3 miles. Hence, reducing walking time to 2 minutes would result in reducing the total distance walked from 0.3 miles to 0.1 mile. The implications are clear from this example that in order to increase modal split for choice bus users significantly, large investments must be made in the transit system.

The second equation estimates choice transit usage for those trips where a rapid transit mode is used. In this case, Figure III-4 shows that the model is sensitive to travel time ratios approaching unity. The model was calibrated for trips originating in South Hills and destined for the CBD. These trips were served by trolleys on predominantly exclusive rights of way. In 1967, approximately 9 percent of all choice transit trips to the CBD were made on the trolleys. Sensitivity analysis showed that for representative data, choice modal split for rapid transit users could be doubled by increasing the running speed from 15 to 30 mph, while keeping other inputs constant. Reducing the headway from 8 to 2 minutes could further increase modal split by an additional 10 percent.[57]

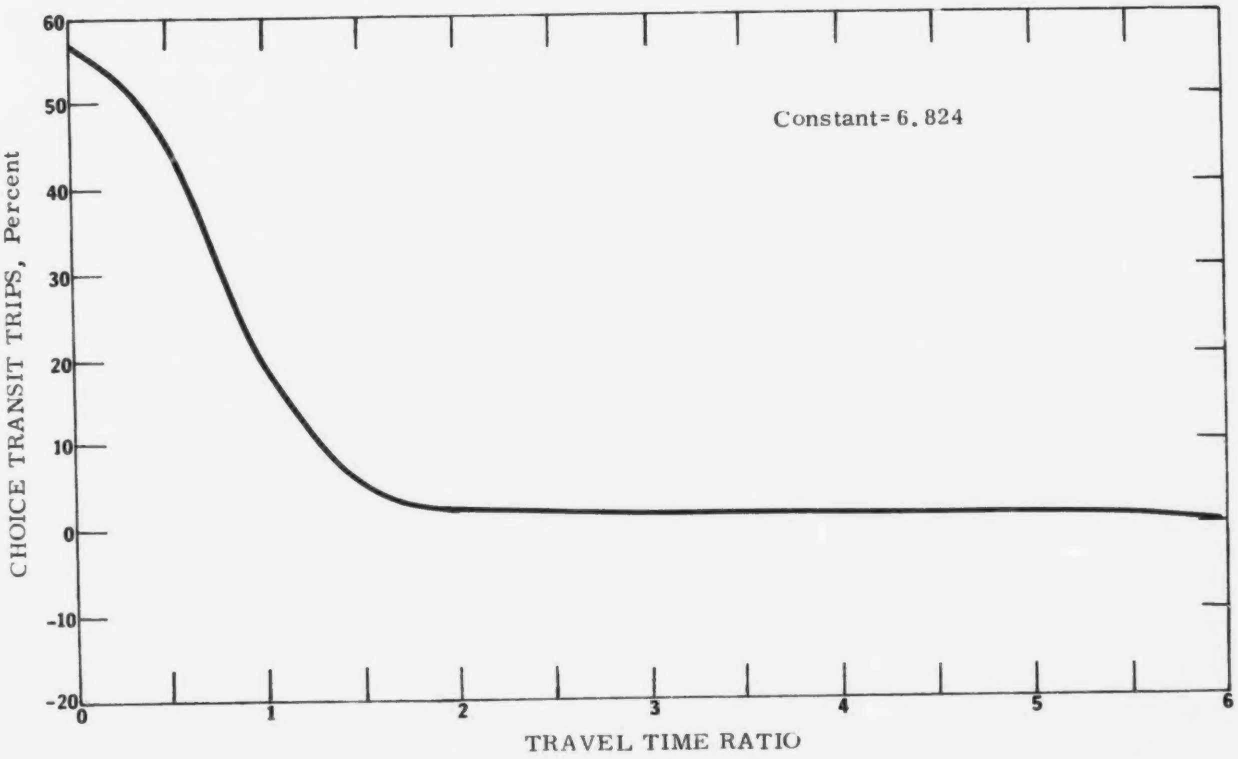

Figure III-4. Percent Choice Rapid Transit Trips Sensitivity Analysis.

Figure III-5 and III-6 relate travel time ratios and employment density to modal split.

By increasing running speed 100 percent, and by reducing headways significantly, the maximum modal split increase would be 0.15 for rapid transit choice users. This would decrease local vehicle miles of travel by 25 percent and total travel by 11 percent in the CBD. If this transit service increase affected 33 percent of the trips attracted to the CBD by 1977, than a 3.67 percent decrease in total travel would result.

j. Transit Fares

The effect of changing the transit fare on transit usage can be estimated based in the following equation:[58]

$$\% \triangle \text{M.S.} = -0.33(\% \text{ T.F.})$$

where:

% M.S. = Percent change in transit usage or modal split

% T.F. = Percent change in transit fare.

The reliability of this equation has been verified under different conditions. As an example of its use, if the present transit fare is 40 cents and it is to be reduced by 100 percent, then the percent increase in transit usage would be 33 percent. If the initial modal split were 50 percent, then modal split would be 58.2 percent after the fare is

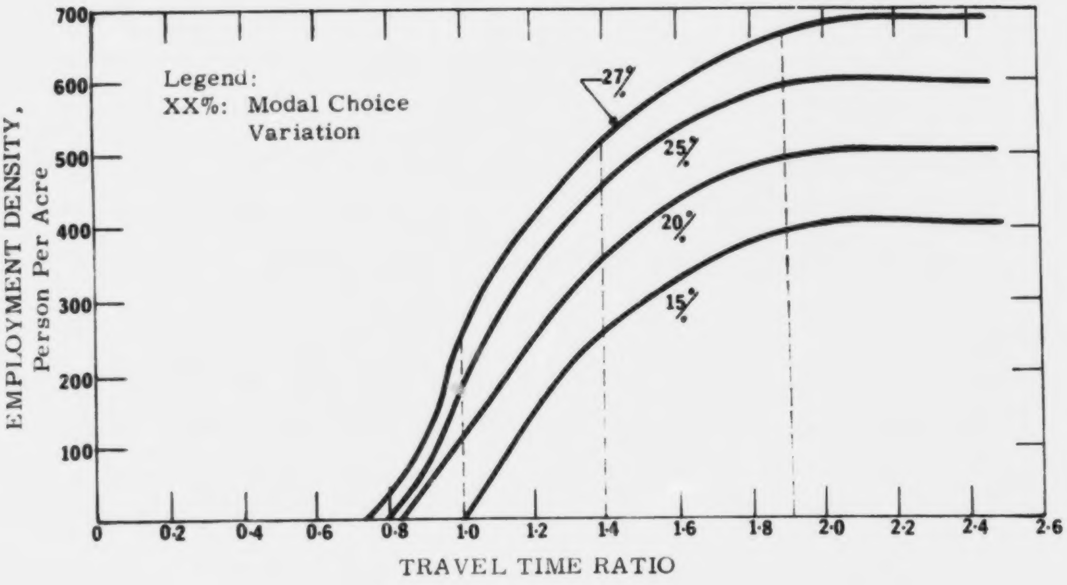

Figure III-5. Isovalue Contours, 15-27% Modal Choice Variations
Employment Density and Travel Time Ratio

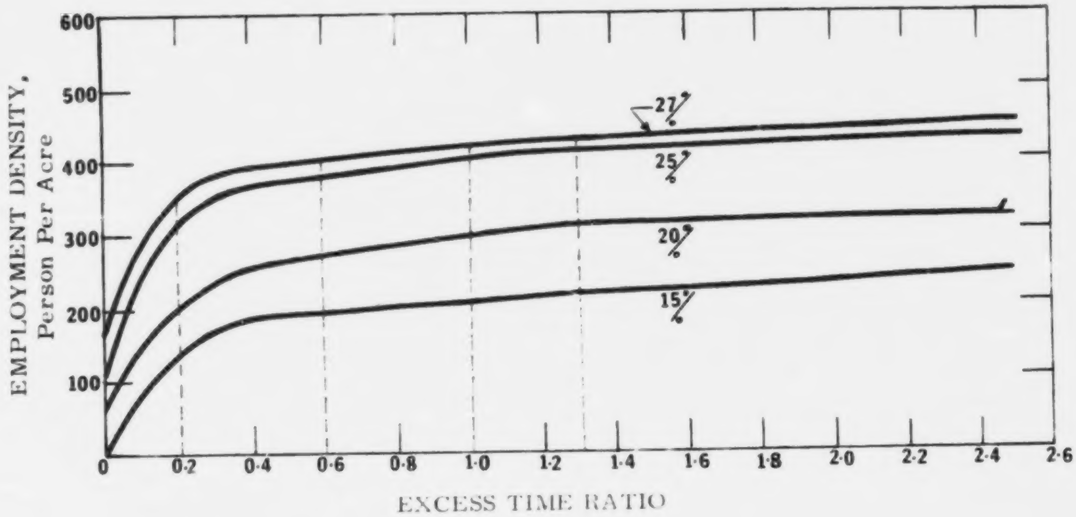

Figure III-6. Isovalue Contours, 15-27% Modal Choice Variations
Employment Density and Excess Time Ratio

reduced. Based on data from Atlanta, a 12 percent increase in transit patronage was experienced during the peak periods, and a 30 percent increase was experienced during the base period.[59] Assuming that the peak period increase was due to persons switching from the automobile mode to transit, and that the base period increase was due to new ridership would indicate that approximately 44 percent of the ridership increase was diverted from automobiles.

For 1977 in Pittsburgh's CBD, daily transit attractions will be approximately 193,000. Therefore, a 100 percent reduction in transit fare would increase daily transit attractions to 256,000, of which approximately 28,000 would have been diverted from automobiles. This increase in ridership would decrease local vehicle miles of travel by approximately 11.6 percent and total travel by 5.2 percent. Figure III-7 shows VMT reduction as a function of fare reduction in the CBD.

k. Tolls

The effect of tolls and road pricing on bridges or streets can be useful in persuading automobile users to use transit or to car pool. One method which could be used to measure the effect of tolls is to relate the toll charge to travel time. It has been estimated that for work trips, users value their time at 5 cents per minute.[60] Therefore, a toll charge of 25 cents per trip would have the effect of increasing travel time by 5 minutes. Applying this revised travel time to the choice modal split and traffic assignment models would result in a higher

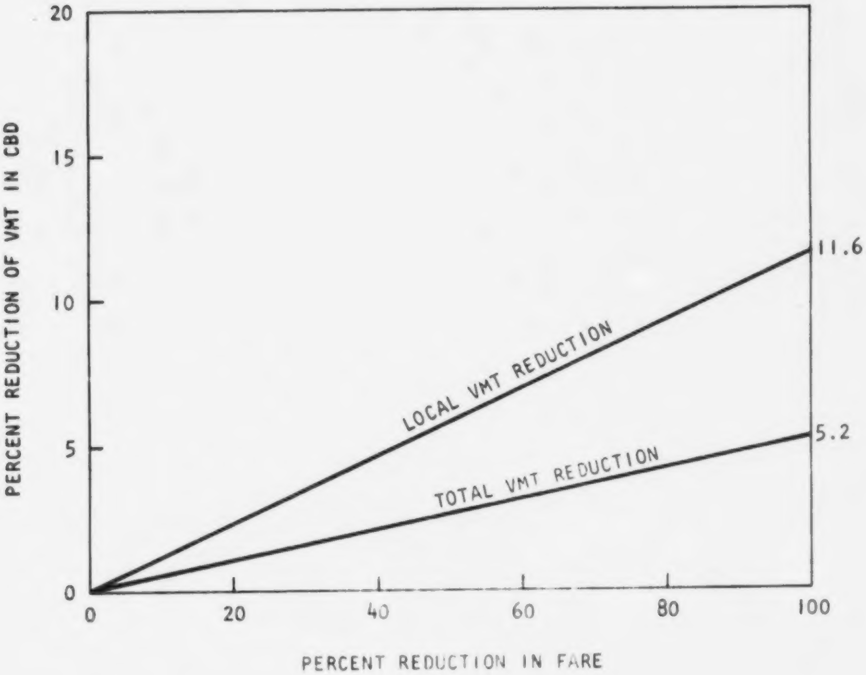

Figure III-7. Percent VMT reduction as a function of transit fare reduction for District 1

modal split and lower volumes of through traffic. The effect of this increase in travel time on modal split has already been discussed in the section on short term transit improvement. If 50 cent tolls were instituted on all accesses to the CBD, then the highway travel time would increase by 10 minutes for work trips. This would reduce the travel time ratio significantly for rapid transit users. The choice modal split would increase by 27 percent for rapid transit users. If rapid transit were available to 33 percent of the CBD attractions, then this would result in a 2.1 percent reduction in local vehicle miles of travel, or approximately 1 percent of total travel in the CBD. An additional reduction could be realized by the diversion of through trips. If one out of every 20 through vehicle trips were diverted, the total vehicle miles of travel would be reduced by an additional 2.75 percent.

1. Parking Time and Charges

The effect of parking charge on choice modal split, assuming employment density is held constant, is estimated in the following equation:[61]

$$M.S. = 0.685\ (P.C.)$$

where:

M.S. = Change in percent choice transit trips

P.C. = Change in long term parking cost, cents/hour

For example, if a 9.7 cents per hour increase in long term parking cost were instituted, then choice modal split would increase by 6.6 percent. This would represent an 87 cent increase in daily parking cost, or approximately $17.50 per month. The existing average daily rate is $2, or $40 per month. Therefore, an increase to $57.50 per month could increase choice modal split 6.6 percent and reduce local vehicle miles of travel in Pittsburgh's CBD by approximately 5.3 percent, and total vehicle miles of travel in the CBD by 2.4 percent. A significant number of these transit users who used to park in the CBD would probably park in fringe parking areas such as the stadium complex, and then utilize shuttle transit service to arrive at the CBD. An increase in car occupancy would also be experienced, but due to the lack of any reliable data, this impact is presently not known.

m. Parking Restriction and Modifications

Restricting on-street parking during peak and off-peak hours effectively increases capacity substantially and increases average speed. It is questionable, however, whether a significant reduction in emissions would occur due to the probable increase in traffic volume. If a net reduction did occur, its effect would not be substantial unless the strategy were applied to many facilities throughout the district. This is highly unlikely in a CBD, since the probability of having many facilities which still allow on-street parking, especially during peak periods, is low. Time limit restrictions on parking spaces can significantly reduce the supply of long term parkers. Again, this strategy would probably have limited effects in a CBD, since most on-street long term parking has already been banned. Figure III-2 can be used to estimate rate reductions due to speed increases.

n. Vehicle Free Zones

The effectiveness of reducing emissions in the area where vehicles are prohibited would be 100 percent. However, the effect of redistributing the eliminated travel in adjacent zones could be serious and must be examined. This strategy would not have to be implemented for environmental reasons unless emission reductions needed to meet ambient air quality standards were too large to be met by less drastic strategies.

o. Reserved Bus Lanes

The reduction in vehicle miles of travel and emissions due to the implementation of reserved bus lanes can be estimated by determining the reduction in transit travel time and increased highway speeds. The SPRPC choice modal split model for rapid transit usage could be used as discussed earlier. The model does incorporate increases in transit operating speed to estimate corresponding increases in modal split. Under existing conditions in several corridors to the CBD, substantial increases in transit usage could be realized by increasing running speed to 30 mph.

According to the choice modal split for rapid transit usage, instituting reserved bus lanes into the CBD could reduce the appropriate travel time ratio from approximately 1.7 to 1.08. This decrease in travel time would increase transit usage by 0.1435. If rapid transit were available to 25 percent of the non-captive trips to the CBD, then local vehicle miles of travel would be reduced by 3.75 percent, and overall travel would be reduced by 1.69 percent in the CBD.

p. Increase Fuel Tax

The effect of reducing vehicle miles of travel and emissions by increasing fuel tax would not be significant unless the fuel tax were substantial. The increase in cost per gallon of gas could be transformed into an increase in cost to the automobile user per vehicle mile driven. For example, a 25 cent increase in cost per gallon of gas could be equated to an additional user cost of 2 cents per mile. Thus, if the average trip length is 7.5 miles, then the added user cost would be 15 cents. As has already been observed, the impact of a 25 cent fuel tax per gallon of gas would not substantially reduce automobile travel. The 15 cent additional cost per 7.5 mile work trip could be equated to a 3 minute increase in travel time. A 3 minute travel time increase for an automobile user would barely affect transit usage according to the choice modal split model. This does mean, however, that a fuel tax of the magnitude of 50 cents or more could be as effective as instituting tolls and road pricing, and this strategy would have a regional effect on reducing vehicle miles of travel. A substantial fuel tax would also provide automobile users a greater incentive to car pool.

As was shown in the discussion of tolls, a 50 cent toll could decrease total travel in the CBD by 2.75 percent. Thus, under the assumptions previously listed, an 83 cent per gallon increase in fuel tax would be needed to reduce travel by 2.75 percent in the CBD.

q. Car Pools

The voluntary use of car pooling to increase automobile occupancy has not been successful on a large scale basis. The most common used to promote voluntary car pooling is to gather information on origins, destinations, starting and returning times for possible users to eventually try to match driver travel patterns. A recent one-day program in Los Angeles was initiated to promote car pooling and transit usage. Over 100,000 handouts were distributed to the public that informed them of the effort. The use of a computer was offered to companies that wished to set up car pools. Three freeways were monitored before, during and after the program, and no measurable change was recorded.[62] Although this program was based only on one day, it is probable that voluntary car pooling may not in itself increase automobile occupancy significantly. It is felt that simultaneous programs such as increased parking costs in the CBD, or road pricing, should be implemented.

r. Staggered Hours

If the air quality standards are being exceeded during the peak hour, then staggering work hours could reduce emissions greatly during the peak hour. Not only would vehicle miles of travel be reduced during the peak hour, but average speeds would increase. By staggering work hours, the vehicle miles of travel during the peak hour could be reduced by 20 percent, and average speed could increase by 20 percent. This would result in an approximate 12 to 15 percent reduction in emissions. However, if the reduction in emissions is needed in the peak 12 hour period, then staggering work hours would not reduce vehicle miles of travel for the 12 hour period greatly, and the reduction in carbon monoxide and hydrocarbon emissions over the period due to peak hour speed increases would be approximately 2 to 3 percent.

s. Fringe Parking

The development of fringe parking is usually implemented in conjunction with bus service or with a fixed rail rapid transit system.[63] In either case, the goal is to gather users at high volume stations where transit vehicles running on frequent headways can transport the high volume of riders to concentrated destinations. The transit service can consequently run on tight headways and minimize wait time. The fringe parking lot allows potential users to drive to or be dropped off at these stations so that the user has convenient access to transit. Fringe parking in suburban areas which lack extensive feeder service due to low population densities and transit usage affords a potential transit user the opportunity to still utilize the transit system. Fringe parking can also be developed near concentrated areas where emissions need to be reduced. The automobile user could park in the lot and walk or use a shuttle transit service into the dense area. This is applicable in Pittsburgh, for example, in the stadium complex where parking could be utilized by workers in the CBD. It is important to note that the district in which the stadium is located is not projected to experience any increase in VMT since it is assumed that parkers formerly traversed the district on the way to the CBD.

The average existing daily parking cost in Pittsburgh's CBD is $2. If fringe parking were created at nominal cost, then based on the value of time already estimated for work trips, a $2 savings per day could be transformed into 20 minute time savings per trip. It is approximated that the average transit travel time from the fringe lot to the CBD would be 10 minutes. This would result in a net time savings of 10 minutes. The choice modal split model for bus users is not sensitive to transit travel time unless the excess time ratio is reduced. Since the excess time ratio is not reduced by this strategy, the choice modal split for bus users is not expected to change. In 1967, approximately 9 percent of all choice transit trips attracted to the CBD used rapid transit. The choice modal split model for rapid transit users is sensitive to transit travel time. The approximate travel time ratio for rapid transit in 1977 was 1.7. Due to the 10 minute travel time reduction estimated, the travel time ratio for rapid transit would decrease to 1.4. The associated increase in choice modal split for rapid transit users would be approximately 27 percent.

If 33 percent of the trips attracted to the CBD could use rapid transit in 1977, then choice transit usage would increase by 9 percent. This increase in choice transit usage would result in reducing local vehicle miles of travel by 2.1 percent and overall travel by 1 percent.

t. Night Goods Delivery

The vehicle miles generated by heavy trucks in the CBD area account for approximately 7 percent of its total vehicle miles. If half of these trucks were to be allowed into the CBD only during the night or on weekends, then a reduction in emissions of slightly more than 3.5 percent could result during the peak 12 hour period. Although the vehicle miles of travel during the day would not be affected, there would be a redistribution of vehicle miles of travel temporally. Hence, implementing night goods delivery could be effective in reducing local VMT during the 12 hour period by 3.5 percent, but would be ineffective in reducing local VMT for a 24 hour period.

u. Location of Government Offices

The location of government offices could be critical on a short term micro analysis basis or on a long term large area basis. It is known that additional public employment in a district increases the number of work trips which then adds vehicle miles of travel to the system. In the CBD, changes in vehicle miles of travel are highly related to changes in public employment. The location of government offices can be effective in controlling the growth of vehicle miles of travel and can be used to reduce vehicle miles of travel by relocating public office activities from districts which have high vehicle miles of travel, to ones which do not. In Pittsburgh, approximately half of all person trips produced or attracted to the CBD are work trips. This means that approximately half of the vehicle miles of travel generated by trips beginning or ending in the CBD are caused by work trips. The maximum reduction in local VMT by relocating all existing public offices in Pittsburgh's CBD over the next five years would be approximately 7.5 percent. Thus, if 20 percent of the public employees were relocated outside the CBD by 1977, then a 1.5 percent reduction in local VMT could occur.

v. Zoning

Zoning is an important tool in controlling travel within the area. Unlike the strategy of locating government offices, zoning can have a sizable impact in reducing emissions in a short time period. Trip generation projections have been based in large part on expected land use growth. In Pittsburgh's CBD, the control of office space, employment density, and commercial use can affect 75 percent of the local trips. By not allowing further employment and commercial development in the CBD over the next five years,vehicle miles of travel could be reduced 2 to 5 percent. If the growth were cut in half, a 1 to 2.5 percent reduction could occur. Another zoning restriction would be to restrict further parking structures to be built which would drive parking costs up and increase modal split and car pooling.

2. Economic Impact

This stage of the analysis assesses the cost of the various emission-reduction measures in "traditional" economic terms.

Major criteria in the evaluation of economic cost are:

(1) Public capital cost

(2) Public operating and maintenance cost

(3) Private capital cost

(4) Private operating and maintenance cost

(5) Other public and private economic costs directly traceable to measure.

The rating of the alternative strategies with respect to economic cost is presented in Tables III-2 and III-3.

3. Non-Economic Impact

The alternative emission control strategies were also ranked on the basis of other impacts not readily convertible to economic terms. Four such non-economic impacts were examined: social, administrative, legal and technical. The detailed ratings and criteria for the four impacts are listed in Appendix D. Discussions with representatives of local agencies were used to determine various rankings.

Major criteria are:

(1) (Social) compatibility with expressed community objectives

TABLE III-2. RATING OF ALTERNATIVE STRATEGIES ECONOMIC IMPACT

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	5	
Loading Zone	2	
Metering	3	
Information Systems	2	
Source Control		
Retrofit	2	
Inspection	2	
Fuel Conversion	2	
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	5	
Increase Transit Use		
Short Term Transit Impv.	4	
Transit Fares	2	
Tolls	3	
Parking Taxes and Charges	3	
Parking Restrictions	4	
Vehicle-Free Zone	1	
Reserved Bus Lanes	3	
Increase Fuel Tax	3	
Increase Occupancy		
Car Pools	4	
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	3	
Fringe Parking	3	
Night Goods Deliveries	2	
Government Offices	2	
Zoning	3	

* Criteria defined in Table III-3.

** Strategy rated previously in this table

TABLE III-3. ECONOMIC CRITERIA

Rating	Criteria
5.0	Highly cost effective on basis other than emissions reduction. Benefit/Cost ratio on basis other than emissions reduction of greater than 2.0.
4.0	Substantial cost effectiveness on basis other than emissions reduction. Benefit/Cost ratio on basis other than emissions reduction between 1.0 and 2.0.
3.0	Questionable cost effectiveness on basis other than emissions reduction. Benefit/Cost ratio assumed to be in the vicinity of 1.0
2.0	Not cost effective on basis other than emissions r reduction. Cost per percentage area wide emissions roll-back between 0 and $3 million.
1.0	Measure generates almost no benefits other than emissions reduction. Cost per percentage area wide emissions roll-back greater than $3 million.

(2) (Social) compatibility with implied community objectives

(3) (Administrative) ability to administer proposed controls with existing agencies and procedures

(4) (Administrative) ability to implement proposed controls with existing manpower

(5) (Legal) difficulty of overcoming legal obstacles to the implementation of the proposed control strategies

(6) (Technical) probability of alternative being operational technically

The final ration of the alternative strategies with respect to all four non-economic impacts is presented in Table III-4.

4. Political Feasibility

The political feasibility of the various strategies is examined in a separate stage. It is acknowledged that political feasibility may appear to be a surrogate measure for other impacts, such as economic, social, or institutional impacts. However, it is stressed that, in reality, political feasibility can represent an entirely independent dimension which should be separated from other quantifiable impacts. For example, it is likely and perhaps to be expected that certain measures appearing to be highly cost effective in terms of all other observable benefits and costs may still be highly infeasible politically. Examples of this situation are being furnished currently in many states by "no-fault" automobile insurance controversies. Of course, the opposite situation may also prevail; measures that are highly

TABLE III-4. RATING OF ALTERNATIVE STRATEGIES
SUMMARY RATING: NON-ECONOMIC IMPACT

Strategy	Individual Rating*				Final Rating
	Social	Administrative	Legal	Technical	Non-Economic Rating
Reduce Emission Rate					
Traffic Flow Improvements					
Upgrade Existing Streets	5	4	5	5	4.8
Loading Zone	4	2	5	5	4.5
Metering	4	1	2	3	2.5
Information Systems		2	4	2	2.0
Source Control					
Retrofit	2	2	1	2	1.8
Inspection	3	3	2	4	3.0
Fuel Conversion	3	2	1	2	2.0
Reduce Vehicle Miles of Travel					
Reduce Travel Demand					
Four Day Week	5	5	1	5	4.0
Increase Transit Use					
Short Term Transit Impv.	5	3	5	5	4.5
Transit Fares	5	3	2	5	3.8
Tolls	3	1	1	5	2.5
Parking Taxes and Charges	4	4	5	5	4.5
Parking Restrictions,	4	3	4	5	4.0
Vehicle-Free Zone	2	1	3	2	2.0
Reserved Bus Lanes	4	1	3	3	2.8
Increase Fuel Tax	4	5	3	5	4.3
Increase Occupancy					
Car Pools	4	4	1	4	3.3
Tolls	**	**	**	**	**
Metering	**	**	**	**	**
Vehicle-Free Zones	**	**	**	**	**
Parking Taxes and Charges	**	**	**	**	**
Shift Travel Patterns					
Staggered Hours	3	4	1	4	3.0
Fringe Parking	3	3	5	4	3.8
Night Goods Deliveries	3	4	2	3	3.0
Government Offices	2	4	3	4	3.3
Zoning	2	3	3	4	3.0

* From Tables in Appendix G
** Strategy rated previously in this table

attractive on a total benefit/cost basis may also be politically attractive.

Major criteria used in the rating of political feasibility:

(1) Degree of endorsement by political leadership

(2) Degree of public acceptance

The rating of the alternative strategies with respect to political feasibility is presented in Tables III-5 and III-6.

5. Evaluation Matrix

Table III-7 summarizes the ratings obtained with respect to effectiveness, economic costs, non-economic impacts and political feasibility. Also in this table, these ratings are accumulated and the strategies are ranked on the basis of total rating.

Note that on this basis, the strategies of upgrading existing streets, short term transit improvement, increasing parking charges, implementing fringe parking and requiring inspection and maintenance emerge as the most attractive control strategies. The only other strategy achieving a final rating greater than 3.0 is the four day week. The effects from this strategy depend on voluntary actions, and since the degree to which it would be implemented in 1977 is not predictable, the strategy was not recommended. If a significant voluntary effort does occur by 1977, then the degree to which the recommended program is implemented could be reduced.

TABLE III-5. RATING OF ALTERNATIVE STRATEGIES ON BASIS OF POLITICAL CRITERIA

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	5	Underway, well accepted
Loading Zone	2	Minor but very vocal opposition
Metering	2	Inconsistent with CBD goals
Information Systems	3	No apparent opposition
Source Control		
Retrofit	2	Believed regressive, costly
Inspection	4	Outgrowth of present inspection
Fuel Conversion	3	No reaction, jurisdiction unclear
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	3	Neutral if voluntary
Increase Transit Use		
Short Term Transit Impv.	4	Favored in principle
Transit Fares	3	Mixed positions
Tolls	2	Implied opposition, CBD goals
Parking Taxes and Charges	4	Rates already changing
Parking Restrictions	1	Opposed without transit
Vehicle-Free Zone	1	Large latent opposition
Reserved Bus Lanes	4	Acceptable in principle
Increase Fuel Tax	2	Unlikely; legislative problem
Increase Occupancy		
Car Pools	3	Indifference; considered ineffective
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	3	Hesitant to require
Fringe Parking	4	Moving in this direction
Night Goods Deliveries	3	Acceptable as voluntary measure
Government Offices	1	Incompatible with CBD goals
Zoning	2	Conflict with CBD goals

* Criteria defined in Table III-6

** Strategy rated previously in this table

TABLE III-6. POLITICAL CRITERIA

Rating	Criteria
5.0	Actively endorsed by all levels of public officials. Wide public acceptance. Previous public acceptance of similar measures.
4.0	Endorsed by some levels of government officials. Generally favored by elected officials. General public acceptance likely. Generally favorable reaction to similar adopted measures.
3.0	Position not taken. Public official reaction mixed between endorsement and lack of position. Public reaction indifferent and/or mixed.
2.0	Publicly opposed by some levels of government officials. General political endorsement not probable. Substantial public opposition. Opposition to similar adopted measures.
1.0	Actively opposed by most levels of government officials. Wide public opposition. Widespread public dissatisfaction with similar measures previously adopted.

TABLE III-7. FINAL RATING OF ALTERNATIVE STRATEGIES ALL CRITERIA

Strategy	Sub-Ratings				Final Rating
	Tech. Effectiveness*	Economic*	Non Econ.*	Political*	
Reduce Emission Rate					
Traffic Flow Improvements					
Upgrade Existing Streets	2	5	4.8	5	4.2
Loading Zone	1	2	4.5	2	2.4
Metering	3	3	2.5	2	2.6
Information Systems	1	2	2.0	3	2.0
Source Control					
Retrofit	3	2	1.8	2	2.2
Inspection	4	2	3.0	4	3.2
Fuel Conversion	2	2	2.0	3	2.3
Reduce Vehicle Miles of Travel					
Reduce Travel Demand					
Four Day Week	2	5	4.0	3	3.5
Increase Transit Use					
Short Term Transit Impv.	2	4	4.5	4	3.6
Transit Fares	3	2	3.8	3	2.9
Tolls	4	3	2.5	2	2.8
Parking Taxes and Charges	3	3	4.5	4	3.6
Parking Restrictions	2	4	4.0	1	2.8
Vehicle-Free Zone	5	1	2.0	1	2.3
Reserved Bus Lanes	2	3	2.8	4	3.0
Increase Fuel Tax	2	3	4.3	2	2.8
Increase Occupancy					
Car Pools	1	4	3.3	3	2.8
Tolls	**	**	**	**	**
Metering	**	**	**	**	**
Vehicle-Free Zones	**	**	**	**	**
Parking Taxes and Charges	**	**	**	**	**
Shift Travel Patterns					
Staggered Hours	2	3	3.0	3	2.8
Fringe Parking	2	3	3.8	4	3.2
Night Goods Deliveries	2	2	3.0	3	2.3
Government Offices	2	2	3.3	1	2.1
Zoning	2	3	3.0	2	2.5

* Summarized from Tables

** Strategy rated previously in this table

IV. RECOMMENDED TRANSPORTATION CONTROL PROGRAM AND IMPACT ON AIR QUALITY

A. RECOMMENDED PROGRAM

Based on the results of the four ratings developed for each control strategy and the 15.9 percent carbon monoxide emission reduction required in the Golden Triangle, Zone 1 for 1977, the following four part transportation control program is recommended.

The first control strategy is the implementation of an inspection and maintenance program which is estimated to reduce carbon monoxide emissions by approximately 9 percent. Although not rated high in the cost ranking, its effectiveness is reducing CO emissions in the CBD was surpassed only by creating a vehicle free zone. This strategy was also recommended because it would not only be instrumental in achieving the 1977 air quality standards, but would be vitally needed in the long-term air quality program. The expected benefits derived from the significant national investment,which will be incurred when producing and installing vehicle anti-pollution devices, could be substantially reduced if these devices are allowed to deteriorate, to be disconnected or to be improperly used. If this strategy were not implemented, the consequences of achieving the 1977 air quality standards would be monumental in limiting urban mobility in the CBD. An alternative program to meet the 1977 standard in the CBD without inspection and maintenance would require significant transit improvement in terms of busways and overall travel time reductions which would increase transit usage by approximately 44 percent, reduct transit fares by 100 percent, increase daily parking costs in the CBD by $2.34, reduce parking demand by 33 percent, and require the development of extensive fringe parking.

The second transportation control strategy in the recommended program is to continue aggressively with upgrading the existing street system, in the form of the TOPICS program and its probable successor. A 12 hour and daily overall speed increase of 2 percent is estimated to occur by 1977 due to these traffic flow improvements. The expected reduction in carbon monoxide and hydrocarbon emissions would be approximately 1.4 percent for the 12 hour and daily periods.

The third transportation control strategy would be to increase long-term parking costs by $1.45 per day. This 16.1 cent per hour increase would increase choice modal split by 11 percent. This results in reducing local vehicle miles of travel by 8.4 percent and total travel by 3.8 percent. The reduction in parking demand would be approximately 8.4 percent less than the existing demand. Since the parking authority presently has control over approximately 6,000 spaces in the CBD, strong upward pressure would be exerted on rates at the remaining privately owned facilities, and these rates would tend to follow the authority's. Parking demand elasticity suggests that no revenue loss would be experienced by private facility owners.

Besides increasing transit usage, a $1.45 increase in the daily cost would also encourage all day parkers in the CBD to park their cars in the fringe lots. This increase in parking costs would reduce VMT in Zone 1 by 1.7 percent and reduce parking demand in the CBD by approximately 3.6 percent. The two existing fringe parking areas are located at the stadium and civic arena complexes.

Together, their existing parking supply would be adequate to meet the demand diverted from the CBD. Frequent transit shuttle service could be implemented to link the fringe lots to the CBD. The creation of fringe parking lots was not considered at this point since it was believed that these high initial cost projects should be planned with long range transit improvements. It was felt that construction of close-in (1-3 miles) fringe parking lots could prove to be inconsistent with the long term goal of rapid transit.

Although the total reduction in parking demand is projected to be 12 percent, this does not imply that parking supply could be reduced by 12 percent. The present parking demand-to-supply ratio is approaching a value of one. In order to properly and efficiently provide parking for users, this ratio should be in the vicinity of 0.85. Therefore, a 12-percent reduction in parking demand would reduce the parking demand-to-supply ratio to an acceptable level in the CBD and would not necessitate reducing the parking supply. Also, the parking demand reduction would probably reduce the number of illegal parkers and therefore improve traffic flow.

The last transportation control strategy in the recommended program is the improvement of the transit system. An increase in modal split

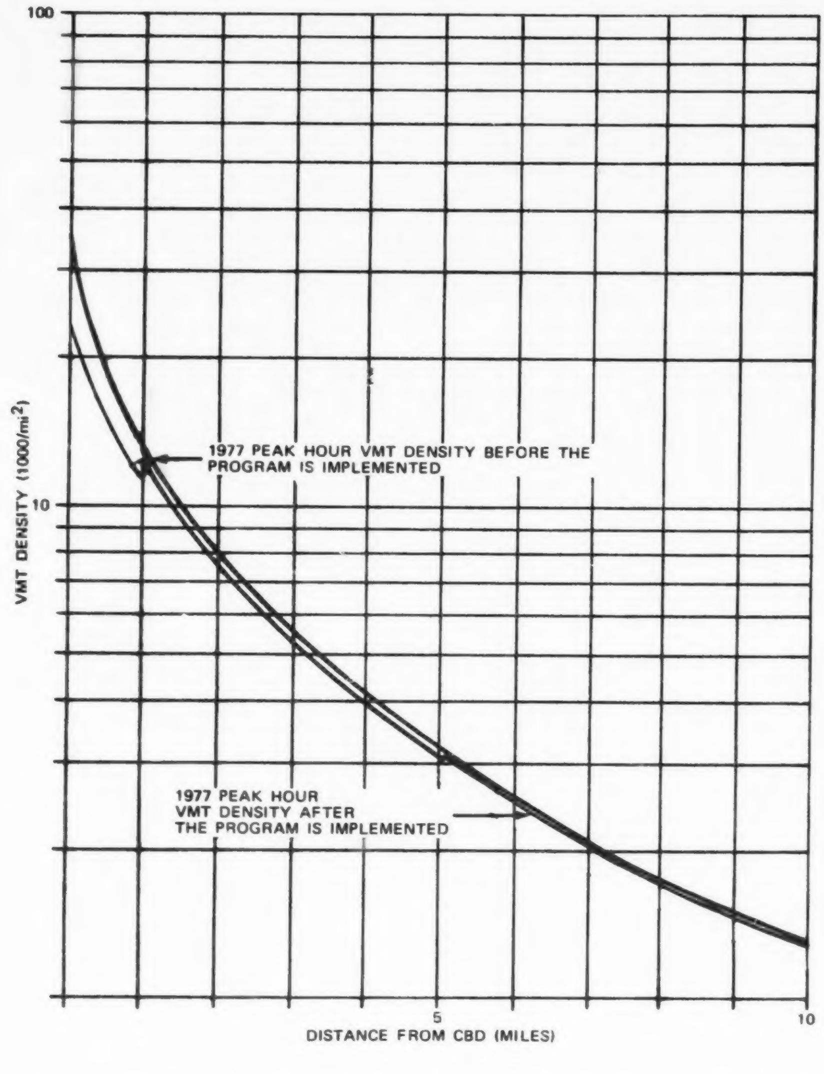

Figure IV-1. Peak Hour VMT Density (1000/mi^2) vs. Distance from CBD (miles) Pittsburgh.

TABLE IV-1

PROJECTED VMT REDUCTIONS FOR 1977 AFTER THE RECOMMENDED CONTROL PROGRAM IS INSTITUTED

(PERCENT REDUCTION)

Districts	Daily	Peak 12 Hours	Peak Hour
1	5.5	7.3	18.3
2-20	1.5	1.9	4.9
21-51	.4	.5	1.3
52-72	.08	.11	.27
Region	.43	.57	1.44

of 5 percent to the CBD was assumed in the initial determination of 1977 vehicle miles of travel. This is based on the assumption of increased employment density in the CBD and some non-capital intensive improvements in the transit system. In order to increase modal split over the next five years, it is recommended that express bus service be instituted to the CBD and that maximum use of traffic engineering techniques (bus priority signal systems, one-way streets, etc.) be pursued.

Figure IV-1 shows a linear approximation of the 1977 peak hour VMT density as a function of the zone's distance from the CBD before and after the control program is instituted. Table IV-1 summarizes the approximate 1977 VMT reductions projected after the Recommended Control Program is implemented.

B. IMPACT ON AIR QUALITY OF RECOMMENDED STRATEGIES

(1) The reductions expected from the several strategies are as follows:

1972 CO emissions from motor vehicles, Zone 1	27,543 kg/day
Less expected reduction from FMVECP (49.8 percent of baseline)	13,714
1977 "no strategy" emission rate of CO, Zone 1 only	13,829
Less 1.4 percent reduction expected from traffic flow improvements	194
	13,635
Less 5.5 percent reduction expected from parking strategies and improvements in short-term mass transit	760
	12,875

Less 9.0 percent reduction expected from inspection and maintenance program	1,159
	11,716
Less 8.2 percent reduction expected from retrofit program (oxidizing catalytic converters on 1968-1974 model year cars)	961
	10,755 kg/day

(2) The net emissions resulting from the above combination of strategies represents a 22.3 percent rollback from the expected 1977 "no strategy" emission rate. Since a reduction of only 19.6 percent from the 1977 vehicular emission rate is required to meet the Federal standards, the combination of strategies listed above represents an "overkill" of some 2.7 percent. In this connection, it should be pointed out that our contract and instructions from the EPA call for a transportation control program that will meet the standards for CO and O_x by 1977. If it is deemed advisable, in light of the considerable degree of uncertainty surrounding all the numbers in this report, to try for a level which will exceed the standard, then the above program will provide such a cushion.

(3) The above strategies are not listed in order of desirability. The priority listing is as follows:

(a)	Inspection and maintenance (mandatory program): (No decrease in VMT)	9.0% decrease in CO emission
(b)	Traffic flow improvements through the upgrading of existing streets (no decrease in VMT)	1.4% decrease in emissions
(c)	Increase parking rates, fringe parking, and improved short-term mass transit (does decrease VMT)	5.5% decrease in emissions
(d)	Retrofit program — oxidizing catalytic converters on 1968 to 1974 model year cars (no decrease in VMT)	8.2% decrease in emissions

(4) The interested reader is referred to the draft amendments to 40 CFR 51, Requirements for Preparation, Adoption and Submittal of Implementation Plans — Transportation Control Measures, the latest version of which is dated 14 November 1972, for further information on the inspection and maintenance and retrofit options listed above.

V. IMPLEMENTATION OBSTACLES

The following agencies participated in meetings and discussions concerning implementation obstacles:

Southwestern Pennsylvania Regional Planning Commission
Pennsylvania Department of Transportation
Pittsburgh Department of City Planning
Pittsburgh Public Parking Authority
Port Authority of Allegheny County
Allegheny County Transportation Department

A. INSPECTION AND MAINTENANCE

Legislative action on at least a regional basis is required for the effective implementation of an inspection and maintenance program. The most likely form of such action is the adoption of a uniform maintenance and inspection measure by all counties in the SPRPC region, or perhaps in western Pennsylvania. In the absence of total regional agreement to proceed with a program, legislation could be adopted by individual counties, and even by the City of Pittsburgh. However, exceptions to a uniform regional policy would seriously erode the effectiveness of the measure.

The possibility of State or even Federal adoption of an inspection and maintenance program is a factor influencing the use of such measures at a more local level. Transitional problems should be anticipated in the adoption of measures at a local or regional level.

The overlaying of a regional inspection and maintenance program on the existing inspection mechanisms will require substantial planning and legislative effort.

Technical procedures required for an inspection and maintenance program represent "off the shelf" capabilities, and no further technical development is foreseen. It is expected that the program will function as an extension of the current vehicle inspection procedures. A technical implementation time of one year (from completion of legislative and planning activity to commencement of inspection) is projected.

It is anticipated that the program will involve an increased administrative effort on a permanent basis. The incorporation of this additional administrative effort into the existing state inspection administrative machinery requires careful planning and legislation. Similarly, allocation of the costs of additional administration will require detailed planning. Uniform legislation throughout the region will be necessary to initiate any additional administrative machinery.

It is likely that objections will be made to any inspection and maintenance program on the grounds that its cost to motorists is regressive with respect to personal income. If these objections become serious enough to jeopardize the adoption of the program, then it will be necessary to devise methods of reducing or eliminating the "user cost" aspect of the program. This could be accomplished by additional fuel taxes, local registration fees, etc., applied to all motorists in the region.

Potential political obstacles involve the generation of support, on a regional basis, for problems that are identified on a subregional basis. Another potential source of political resistance may arise from the out-of-pocket costs associated with the program. However, experience with out-of-pocket costs for safety related automobile equipment indicates that objections diminish as the control becomes more widespread.

The primary economic obstacle is the capital expenditure required to plan and initiate the measure. Specific funding sources (if any) for this type of program are not clearly identified. In estimating capital costs required to implement an inspection and maintenance program, these assumptions were made: A 20-minute inspection time, 60-hour week, $35,000 per lane for equipment, approximately 1.5 million vehicles to test in 1977, $145,000 per lane for land and building capital costs, and an 80 percent utilization factor. Utilizing the assumptions above, approximately 210 lanes would be needed at an approximate capital cost of $180,000 per lane. The approximate capital cost for the program would therefore be $38 million.

B. UPGRADE EXISTING STREETS

It is expected that this strategy can be implemented with little resistance. Legislation has already been provided for this type of program and it is expected that additional programs will, in the near future, supplement existing programs for the upgrading of urban streets. It is also anticipated that Federal allocations for this type of improvement program will increase significantly in the near future.

Administrative difficulties in the implementation of future urban street improvement programs are expected to receive attention at the State and Federal levels. Significant administrative capacity for this type of program already exists at the local level.

Street improvement programs typically are estimated to yield a benefit/cost ratio of 2.0 or greater, based on delay and accident reductions. Since the costs of this program are already justified on a delay and accident reduction, the cost for emission reductions would be minimal.

C. PARKING RATES AND FRINGE PARKING

The public parking program in Pittsburgh affords opportunities to implement some emission control strategies with a minimum of risk due to obstacles that jeopardize other measures. The Authority has demonstrated a capability for aggressive implementation of programs and a willingness to support its programs against various pressures.

No serious legislative difficulties are foreseen in the implementation of the recommended measures of parking rate changes and fringe parking. The legal capability to undertake both of these measures exists and has been exercised previously.

Additional studies of demand elasticity, fringe parking availability and accessibility, and triangle parking rate structure will be required. Depending on the scope of these studies, temporary supplementation of the Parking Authority's planning capability may be required. Control of the ongoing parking program should not add materially to the Authority's responsibilities, however.

Any effort to contain the parking supply in the Triangle will draw opposition on the grounds that such measures conflict with the stated objectives of maximum physical growth in this area. Thus, it is important that proper attention be given to the infrastructure necessary for the successful diversion of long-term parking from the triangle area (shuttle transit, pedestrian routes, escalators, etc.).

The economic impact of the recommended control strategies will require careful analysis. In particular, the effect on net parking revenues resulting from the proposed rate changes will need careful evaluation. A decrease in such revenues, while relatively small in comparison to the total costs of other recommended emission control strategies, could have a major impact on the operation of the Authority, and this possibility must be explored in depth.

Vocal opposition from affected parking facility users can be expected and should be met with a public relations type of program explaining the need for the measures and the consequences of alternative measures.

D. SHORT TERM TRANSIT IMPROVEMENTS

Implementation of any capital-intensive transit improvements is considered infeasible due to time limitations and legal complications. However, it is expected that short range transit improvements with low capital costs can proceed by 1977. No legislation or resolution of legal problems is necessary for improvements such as express bus service, shuttle service to parking areas or utilization of traffic engineering techniques to improve bus operations.

The planning of short range improvements presents some difficulties and will probably involve a detailed study of alternatives. Technical obstacles are minor, since short term operation changes do not represent a significant departure from existing technology.

Some political opposition to short term transit improvements is probable, either on economic grounds or because even short term measures are closely identified with controversial long range transit issues in Pittsburgh. It is possible that this opposition may be reduced by "outside" funding of improvements and by careful efforts to dissociate short term programs from existing transit proposals.

The funding of short term transit improvements appears to be a significant obstacle which is best overcome by careful review of available capital improvement programs and timely action toward such funding. Approximately 16,200 additional transit users are estimated to arrive in District 1 during the peak hour for 1977. Assuming a load of 50-70 passengers per bus would indicate a need for approximately 290 buses. Assuming $40,000 per bus would result in an $11.6 million capital cost.

VI. SURVEILLANCE AND IMPLEMENTATION PROCESS

A. INTRODUCTION

This section deals with the establishment of the schedule for implementation and surveillance of the recommended control strategy program. An implementation schedule assuming existing conditions is developed first. Serious potential inadequacies arising from the application of a static program are then identified. A methodology for overcoming these difficulties is suggested, and its application to the recommended air quality improvement program is outlined.

B. SURVEILLANCE AND IMPLEMENTATION: CURRENT CONDITIONS

Figure VI-1 indicates a schedule for the implementation of the recommended control strategy program (see Section IV). Implementation of the program is staged to achieve the target percent reduction in emissions (see Chapter II). Projected implementation times for various control measures represent a schedule designed to meet 1977 air quality standards, with reasonable slack times (10 to 20 percent) incorporated for all stages of implementation. Hence, the schedule is developed by "working backwards" from the 1977 deadline and programming the implementation of improvements on this basis.

It should be noted that a "crash program", oriented toward maximum emission reductions within a minimum time period, could result in a more condensed schedule, with nearly simultaneous undertaking of control measures at the outset of the improvement in the immediate future. However, it should also be recognized that this type of programming of emission reduction control measures would involve higher implementation costs, reduced cost/effectiveness and public acceptance problems not accounted for in the rating of strategies that accompanied the analysis in this report.

The PERT chart (Figure VI-1) indicates that, of the four major strategies recommended in the emissions reduction program, two are independent in the sense that the critical paths of their implementation processes are not a function of the implementation of other measures. Specifically, the implementation of the arterial street improvement program and the maintenance and inspection programs are not related to progress on the other recommended strategies. However, the recommended strategies of parking rates, fringe parking and short term transit improvements are closely related, and the critical task for the implementation of the entire subpackage of improvements is derived from elements in the implementation phases of each of the various individual strategies.

The activities and events outlined in the chart in Figure VI-1 are discussed in further detail in the section of this report dealing with implementation obstacles.

C. INADEQUACIES OF A STATIC SURVEILLANCE PROGRAM

The PERT approach has long been established as a useful tool for the planning and execution of complex programs. Adaptations of this methodology have also proven useful in circumstances where only sparse

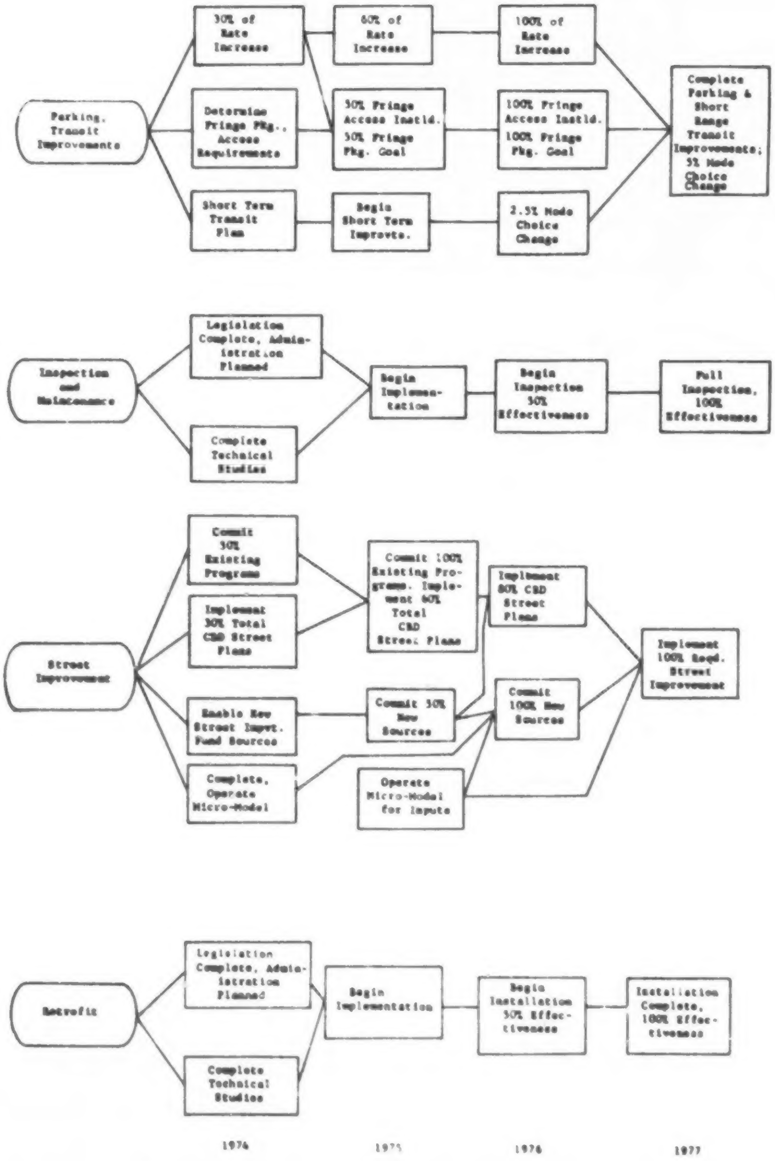
Parking, Transit Improvements
30% of Rate Increase
60% of Rate Increase
100% of Rate Increase
Determine Fringe Pkg., Access Requirements
30% Fringe Access Instld. 30% Fringe Pkg. Goal
100% Fringe Access Instld. 100% Fringe Pkg. Goal
Short Term Transit Plan
Begin Short Term Improvts.
2.5% Mode Choice Change
Complete Parking & Short Range Transit Improvements; 5% Mode Choice Change
Inspection and Maintenance
Legislation Complete, Administration Planned
Complete Technical Studies
Begin Implementation
Begin Inspection 50% Effectiveness
Full Inspection, 100% Effectiveness
Street Improvement
Commit 50% Existing Programs
Implement 30% Total CBD Street Plans
Commit 100% Existing Programs. Implement 60% Total CBD Street Plans
Implement 80% CBD Street Plans
Enable New Street Impvt. Fund Sources
Commit 50% New Sources
Commit 100% New Sources
Complete, Operate Micro-Model
Operate Micro-Model for Inputs
Implement 100% Reqd. Street Improvement
Retrofit
Legislation Complete, Administration Planned
Complete Technical Studies
Begin Implementation
Begin Installation 50% Effectiveness
Installation Complete, 100% Effectiveness
1974
1975
1976
1977

Figure VI-1. Implementation schedule for the recommended transportation control program.

data is available with respect to activity execution time. However, two serious limitations of the PERT approach emerge as the approach is considered for the Pittsburgh emissions reduction program:

- The PERT process assumes a known objective. Although quantitative variations in the objective can be accommodated under the process, the complete substitution of one objective by another objective cannot be systematically accommodated by a single PERT process.

- The PERT process depends on known activities (i.e., the "lines" connecting the event nodes of the PERT network). As noted earlier, the PERT process can function with nothing more than estimates of the times required for these activities. However, the PERT process does not systematically accommodate the removal of an activity entirely, nor its replacement by other activities.

It is highly probable that the objectives of any emission reduction program will, by 1977, vary significantly from objectives now adopted or adopted in the near future. At least two significant factors contribute to this likelihood:

- The definition of the problem may change. As surveillance devices and techniques are improved, entirely new parameters of air quality may be defined. For example, it is expected that very localized measurements of air quality will be routine in the near future. The mere disaggregation of the geographic area considered as a single unit for the measurement of air quality will change the nature of any air quality improvement objective drastically. Thus, it is possible that air quality may eventually be defined on the basis of areas smaller than a conventional city block, rather than on the presently used zones of more than a square mile.

- The programmed activities may not occur, and activities not programmed at present may be included. Some uncertainty must be assumed along with most activities in the implementation program for Pittsburgh. These uncertainties arise primarily from the fact that the technical effectiveness of most suggested strategies is not accurately known at this point. Hence, the assumption of a certain reduction in emissions as a result of the adoption of a strategy is only an estimate at this point. In addition to uncertainties concerning technical effectiveness, there are also uncertainties involving the political feasibility of adopting any recommended measure.

As noted earlier, it is also possible that air quality improvements measures not now considered may prove to be feasible in the future. Furthermore, it is also possible that measures not presently known or considered as emission control strategies will be developed by 1977.

REFERENCES

LIST OF REFERENCES

1. Air Management Services, Department of Public Health, Philadelphia, Pennsylvania, Control of Vehicular Air Pollution in a Comprehensive Program, 3 November 1972.

2. Allegheny County Board of Commissioners, Official Information Map, 1971.

3. Allegheny County Bureau of Air Pollution Control (BAPC), records of air quality data for four locations in Allegheny County, 1971-1972.

4. BAPC, Allegheny County Emission Inventory, 1971.

5. ----, Allegheny County Emission Inventory, 1972.

6. BAPC Staff members, informal communications regarding the Air Quality Network in Allegheny County.

7. Anonymous, thesis on automobile emissions in Pittsburgh, undated, 30 pp. plus appendices, tables, and Fig. 1, Map of Allegheny County.

8. Anonymous, "Private Cars Inside City Target of State Environmental Board," Pittsburgh Press, 13 December 1972.

9. Calcagni, John, "Preliminary Assessment of the Oxidant and Carbon Monoxide Problem in Metropolitan Boston," GCA Corporation, Bedford, Massachusetts, 24 October 1972.

10. Commercial Atlas and Marketing Guide, Rand McNally and Co., 1956.

11. Costello, Mary, "Would Free Mass Transit Tempt Drivers?" in Charlotte, North Carolina, newspaper for 13 December 1972.

12. U. S. Environmental Protection Agency (EPA), Guidelines: Air Quality Surveillance Networks, OAP Publ. No. AP-98, May 1971.

13. EPA, Sampling Location Guidelines, November 1971

14. ---, National Primary and Secondary Ambient Air Quality Standards (40 CFR 50), 25 November 1971.

15. ---, Requirements for Preparation, Adoption, and Submittal of Implementation Plans (40 CFR 51), 25 November 1971, amended 17 December 1971 and 30 December 1971.

16. ---, Approval and Promulgation of Implementation Plans (40 CFR 52), 3 February 1972, amended 31 May, 27 July, 22 September, 26 September, and 28 October 1972.

17. EPA, Air Quality Control Regions, Criteria, and Control Techniques (40 CFR 81), 25 November 1971.

18. ---, Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines (40 CFR 85), 25 November 1971, amended 15 January, 8 September (effective 8 October), and 15 November 1972.

19. ---, "Ambient Ozone Measurements, July through September 1971," January, 1972.

20. ---, Compilation of Air Pollutant Emission Factors (revised), OAP Publ. No. AP-42, February, 1972.

21. ---, Evaluating Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas -- An Interim Report, 16 March 1972.

22. EPA, Guide for Compiling a Comprehensive Emission Inventory, Publ. No. APTD-1135, June 1972.

23. ---, "Transportation Control Strategies for State Air Quality Implementation Plans," information on the EPA Contract for Transportation Control Strategies, undated.

24. ---, minutes of the meeting held in Pittsburgh on 28 September 1972 on the project to develop transportation control strategies for Pittsburgh, Pa. Minutes were dated 2 October 1972 and were addressed to Mr. Wassersug from Mr. C. C. Miesse.

25. ---, 40 CFR 51, Requirements for Preparation, Adoption, and Submittal of Implementation Plans -- Transportation Control Measures (Draft), 14 November 1972.

26. ---, Control Strategies for In-Use Vehicles, 29 November 1972.

27. Fox, Raymond D., Development of Transportation Control Strategies for State Air Quality Implementation Plans (Proposal), GCA Corporation, Bedford, Massachusetts, 7 July 1972. (Also Statement of Work)

28. Frohliger, John O., "Study of the Air Quality in the East Street Valley," 1 August 1972.

29. Godin, Gaetan, et al, "Urban Exposure to Carbon Monoxide," Archives of Environmental Health, vol. 25, November 1972, pp. 305-313.

30. Goode's World Atlas (11th ed.), edited by Edward B. Espenshade, Jr.; Chicago, Illinois, Rand McNally and Co., 1960.

31. Graham, J. Donald, P.E., Air Pollution Engineer, BAPC, personal communication, 6 December 1972.

32. Grosset Road Atlas of the United States, Canada, and Mexico, St. Louis, Mo., Diversified Map Corp., 1972.

33. Kircher, David S., and Donald P. Armstrong, An Interim Report on Motor Vehicle Emission Estimation (draft EPA paper), October 1972.

34. Lynn, David A., "Preliminary Assessment of the Carbon Monoxide and Oxidant Problem in the Baltimore Region," GCA Corporation, Bedford Massachusetts, 5 October 1972.

35. National Air Pollution Control Administration (NAPCA), Calculating Future Carbon Monoxide Emissions and Concentrations from Urban Traffic Data, by Wayne Ott, John F. Clarke, and Guntis Ozolins, June 1967.

36. NAPCA, Report for Consultation on the Metropolitan Pittsburgh Intrastate Air Quality Control Region, February 1969.

37. National Oceanic and Atmospheric Administration (NOAA), Environmental Data Service, Local Climatological Data -- Annual Summary with Comparative Data, Pittsburgh, Pennsylvania, 1971.

38. Commonwealth of Pennsylvania, The Vehicle Code, PL 58 of 1959, amended by PL 590 of 1970 and PL 154 of 1972 (Sections 834(a) and 850, approved 16 June 1972, deal with emission control devices on motor vehicles).

39. -----, Air Pollution Control Act, 8 January 1960, amended 26 October 1972.

40. -----, Air Quality Implementation Plan, January 1972, (several components thereof, as follows):

    A. "Information Concerning the Implementation Plan," Allegheny County Health Department, Bureau of Air Pollution Control, 18 November 1971.

    B. Letter, 14 January 1972, to Mr. Ruckelshaus from Mr. Gilbertson, requesting a two-year extension for compliance with that section of the law dealing with control of CO and oxidants in the Pittsburgh region.

    C. "Control Strategy Evaluation for the Commonwealth of Pennsylvania," 31 January 1972.

    D. "Air Basin Growth Rate Analysis," prepared by IBM for the EPA, 23 February 1972.

    E. "Additions and Clarifications to Pennsylvania's Implementation Plan," 4 May 1972.

    F. Letter, 5 May 1972, to Mr. Ruckelshaus from Governor Shapp, stating the requirement for transportation control strategies to achieve the federal standards for CO and HC by 1977, and the plans for same.

G. Letter, 3 July 1972, to Mr. Triplett from Mr. Chleboski, giving additional information on the Allegheny County Air Pollution Control Program as it relates to the Pennsylvania Implementation Plan.

H. Letter, 1 August 1972, to Mr. Triplett from Mr. Chleboski, stating that the Allegheny County Air Pollution Control Regulations now have the force of law, (in the form of an Ordinance by the Board of Commissioners of Allegheny County).

I. "Addendum to Pennsylvania's Implementation Plan," undated.

J. Other correspondence among various government agencies, some of which was incorporated as part of the Implementation Plan.

41. Pittsburgh Regional Planning Association (PRPA), Prelude to the Future, the PRPA Annual Report for 1968.

42. PRPA Annual Report for 1970.

43. Record, Frank A., "Preliminary Assessment of the Oxidant and Carbon Monoxide Problem in Salt Lake City," GCA Corporation, Bedford, Massachusetts, 22 September 1972.

44. Road Atlas, United States, Canada, Mexico, Rand McNally and Co., 1963.

45. Schuck, E.A., et al, "Relationship of Hydrocarbons to Oxidants in Ambient Atmospheres," Journal of the Air Pollution Control Association (JAPCA), vol. 20, no. 5 (May 1970), pp. 297-302.

46. Southwestern Pennsylvania Regional Planning Commission (SPRPC), SPRPC Reports, Annual Report Issue, September 1971

47. SPRPC, Transportation Planning -- Cycle I (revised 10 July 1972).

48. SPRPC Staff members, informal communications regarding the plans for control of emissions from both vehicular and non-vehicular sources of air pollutants.

49. Voorhees, Alan M., and Associates, Inc., correspondence with staff members on matters pertaining to traffic data and transportation control strategies.

50. Williams, Jonathan, "Improved Mass Transit Viewed Pollution Cure," Pittsburgh Post-Gazette, 14 December 1972.

51. Memorandum Report Recommendations for the Pittsburgh Transportation Development Program. Alan M. Voorhees and Associates. McLean, Virginia. May 1972. 20 pages.

52. Development of Trip Generation Models for the Southwestern Pennsylvania Region. Southwestern Pennsylvania Regional Planning Commission. Pittsburgh, Pennsylvania. May 1972. 100 pages.

53. Environmental Protection Agency Preliminary Draft. Transportation Control Measures. October 26, 1972.

54. Environmental Protection Agency Preliminary Draft. Transportation Control Measures. October 26, 1972.

55. Evaluating Transportation Controls to Reduce Major Vehicle Emissions in Major Metropolitan Areas. Institute of Public Administration. Washington, D.C. March 1972. Pages 2-1-2-24.

56. Desimone, V. R. The 4-Day Work Week and Transportation (Joint ASCE-ASME Transportation Engineering Meeting. Seattle. July 26-30, 1971.) 21 pages.

57. Modal Split Model for Southwestern Pennsylvania. Southwestern Pennsylvania Regional Planning Commission. Pittsburgh, Pennsylvania. April 1972. 53 pages.

58. Curtin, J. F. Effect of Fares on Transit Riding. Highway Research Record. 213: 8-20, 1968.

59. Atlanta's Reduced Transit Fare Experience. Metropolitan Atlanta Rapid Transit Authority. (Urban Mass Transportation Administration UTPS User Symposium. July 27-28, 1972.) 6 pages.

60. The Hampton Roads Joint Transportation Study. Alan M. Voorhees and Associates and Hammer, Greene, Siler, Associates. McLean, Virginia. October 1970. 77 pages.

61. The Hampton Roads Joint Transportation Study. Alan M. Voorhees and Associates and Hammer, Greene, Viler, Associates. McLean, Virginia. October 1970. 77 pages.

62. Meyers, P., J. Walker. The Effects of "Share A Ride Day" on Los Angeles Freeways. Traffic Engineering. 42(11): 35-37, August 1972.

63. Deen, T. B. A Study of Transit Fringe Parking Usage. Alan M. Voorhees and Associates. Washington, D.C. 40 pages.

64. Development of Trip Distribution Models for the Southwestern Pennsylvania Region. Southwestern Pennsylvania Regional Planning Commission. Pittsburgh, Pennsylvania. April 1972. 54 pages.

65. An Analysis of Urban Highway Public Transportation Facility Needs. U.S. Department of Transportation. Washington, D.C. Volume I. January 1972. 92 pages.

66. Capelle, D. G. Feasibility and Evaluation Study of Reserved Freeway Lanes for Buses and Car Pools. Alan M. Voorhees and Associates. Los Angeles, California. January 1971.

67. Goldenberg, M., R. Keith. The Effect of Land Use Planning and Transport Pricing Policies in Express Transit Planning. Highway Research Record. 305: 146-155. 1970.

68. A Guide for Reducing Automotive Air Pollution. Alan M. Voorhees and Associates, Inc. Ryckman, Edgerly, Tomlinson and Associates. McLean, Virginia. November 1971. 38 pages.

69. Bellomo, S. J. Providing for Air Quality and Urban Mobility. (Fifth Annual Summer Meeting Highway Research Board. Madison. July 31-August 2, 1972.) 51 pages.

APPENDIX A

APPENDIX A

DAILY MAXIMA OF HOURLY CO CONCENTRATION FOR THE DOWNTOWN PITTSBURGH ZONE, WITH MONTHLY MAXIMA

(July 1971 to June 1972)

HOUR	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	MAX FOR THE HOUR
1	13	12	11	22	18	20	(1t9)	14	22	15	16	12	21.8
2	14	12	12	18	11	16	(1t9)	10	17	15	12	10	18.4
3	12	12	4	13	11	15	(1t9)	10	12	12	8	8	14.6
4	13	11	10	13	10	11	(1t9)	10	9	11	8	8	13.0
5	12	11	6	13	9	(1t9)	(1t9)	10	9	9	9	9	13.0
6	13	12	15	13	10	(1t9)	(1t9)	8	9	7	10	11	15.1
7	32	21	16	16	13	(1t9)	(1t9)	8	12	9	15	18	31.8
8	32	31	19	27	20	(1t9)	11	11	18	11	21	23	32.1
9	20	22	17	24	28	(1t9)	15	11	24	20	22	18	28.4
10	13	34	24	24	26	(1t9)	11	9	27	14	14	19	34.0
11	13	38	34	44*	34	14	21	11	23	11	12	17	44.2*
12	13	18	20	16	39**	14	9	12	14	(1t9)	12	16	38.6**
13	(~~80.8~~)	19	14	15	11	14	7	17	14	(1t9)	20	17	20.0
14	12	15	20	(~~45~~)	12	13	7	22	16	(1t9)	18	17	22.3
15	16	15	13	18	7	13	8	19	15	(1t9)	11	16	19.0
16	19	13	19	19	7	13	12	13	17	(1t9)	14	22	22.0
17	15	16	18	23	20	15	16	17	19	(1t9)	16	19	22.5
18	12	12	13	15	17	16	21	19	22	(1t9)	14	13	22.0
19	11	12	12	16	22	21	15	12	17	(1t9)	10	9	22.0
20	12	15	11	22	23	14	19	17	18	16	13	10	23.0
21	12	14	11	23	23	23	16	24	21	12	20	11	24.3
22	13	18	9	23	17	22	17	24	15	13	16	12	24.3
23	13	19	10	23	22	24	16	25	12	19	16	16	24.7
24	14	16	10	23	15	25	18	25	12	12	14	13	24.6
AVG.	6.4	8.1	7.1	7.9	5.3	4.6	3.6	5.6	7.5	8.7	6.8	7.2	
MAX.	32.2	37.9	34.2	44.2	38.6	24.6	21.3	24.7	26.8	20.0	21.5	22.0	

Two bad data points have been lined out. "1t9" = less than 9 ppm
*highest recorded 1-hour observation during the period
** second highest reading during the period

TABLE A-2

AVERAGE VALUES OF DAILY HIGH READINGS OF CO CONCENTRATION, DOWNTOWN PITTSBURGH, 1971-1972, WITH AVERAGE TIME OF OCCURRENCE

MONTH	AVERAGE DAILY HIGH CO CONCENTRATION (PPM)	AVERAGE TIME OF OCCURRENCE (HR)	AVERAGE OF TWO HIGHEST READINGS FOR THE MONTH	MONTHLY AVERAGES
June - 1971	14.6	1336	20.75 ppm	8.24 ppm
July	14.0	1200	33.65	6.40
August	16.1	1142	34.50	8.09
September	15.3	1318	34.65	7.06
October	18.1	1336	35.80	7.93
November	13.5	1442	35.00	5.34
December	11.0	1448	23.85	4.58
January - 1972	8.8	1424	20.90	3.61
February	10.7	1506	23.30	5.57
March	13.7	1506	25.00	7.45
April	14.8	1330	21.10	8.66
May	14.0	1324	20.85	6.79
June	12.7	1312	22.45	7.23
July	14.1	1230	27.20	8.45
August	13.0	1230	24.15	8.38

The data from the two right-hand columns have been plotted in Figure II-5.

The "daily high" and "two highest" averages are based on daily maxima only, while the "monthly averages" are based on all hourly readings.

The winter minimum is clearly visible in the left-hand and right-hand columns, but is somewhat obscured in the next-to-right column. A tendency toward earlier maximum readings during the summer is also noted, with the smaller daily maxima during the winter months occurring later in the day.

TABLE A-3

HIGHEST DAILY MAXIMUM CO CONCENTRATIONS (PPM) BY HOUR, WITH DATES

DOWNTOWN PITTSBURGH (ZONE 1)

Period of Record: June 1971 to August 1972

HOUR	HIGHEST DAILY MAXIMUM RECORDED	SECOND HIGHEST DAILY MAXIMUM RECORDED	FREQUENCY OF DAILY MAXIMUM READING, BY HOUR*
01	21.5, 1 Mar 72	19.9, 15 Dec 71	19
02	14.9, 30 Jul 71	14.4, 2 Jul 72	11
03	16.0, 1 Apr 72	10.7, 22 Jan 72	2
04	----- (Daily maxima never occurred at these hours)	-----	0
05	-----	-----	0
06	14.1, 13 Jul 72	-----	1
07	20.6, 23 Jul 71	18.3, 6 Jun 72	18
08	32.1, 8 Jul 71	31.1, 30 Aug 71	53
09	26.8, 21 Mar 72	22.2, 6 Apr 72	35
10	24.2, 27 Sep 71	19.8, 1 Sep 71	23
11	44.2, 1 Oct 71	37.9, 18 Aug 71	32
12	38.6, 3 Nov 71	17.1, 7 Dec 71	11
13	20.8, 22 Jul 71	19.5, 30 Apr 72	11
14	35.2, 21 Jul 71	22.3, 22 Oct 71	11
15	19.5, 26 Apr 72	15.6, 17 Jul 71	13
16	20.9, 7 Jun 71	18.9, 9 Sep 71	25
17	23.1, 6 Dec 71	22.5, 17 Oct 71	40
18	22.1, 29 Mar 72	20.5, 10 Jan 72	29
19	18.3, 14 Nov 71	16.8, 21 Oct 71	4
20	15.3, 13 Dec 71	15.3, 12 Mar 72	14
21	23.2, 2 Oct 71	23.0, 17 Nov 71	19
22	18.3, 14 Aug 71	14.3, 19 Aug 72	8
23	23.6, 11 Jul 72	20.8, 19 Jul 72	23
24	24.7, 29 Feb 72	24.6, 14 Dec 71	26
			428 Data Points

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* See histogram, Figure II-7.

Underlined values are monthly high or second high readings.

Values underlined twice are the highest and second highest recorded at any time during the period of record (See also Table II-3.)

APPENDIX B

APPENDIX B

RUNS OF HIGH HOURLY CO CONCENTRATIONS, PITTSBURGH, ZONE 1 (ppm)

DATE	HOURS	8-HOUR AVG. CONCENTRATION
18 Aug 71	03-10	14.4
	04-11	18.3
	05-12	18.3
	06-13	18.3
	07-14	18.7
	08-15	18.1
	09-16	17.8
	10-17	17.5
1 Oct 71	05-12	16.5
	06-13	18.1
	07-14	19.3
	08-15	20.4
	09-16	20.2
	10-17	20.1
	11-18	20.1
	12-19	16.4
	13-20	16.6
	14-21	16.5
	15-22	16.2
2-3 Oct 71	14-21	16.2
	15-22	17.2
	16-23	18.4
	17-24	19.6
	18-01	20.4
	19-02	20.9
	20-03	21.2**
	21-04	20.2
	22-05	18.7
	23-06	17.2
17-18 Nov 71	17-24	19.8
	18-01	19.5
	19-02	18.8
	20-03	17.4
	21-04	15.8
18 Nov 71	03-10	15.8
	04-11	18.4
	05-12	20.7
	06-13	20.9
	07-14	21.27 *
	08-15	20.3
	09-16	18.7
	10-17	16.2
14-15 Dec 71	15-22	17.0
	16-23	18.4
	17-24	19.8
	18-01	20.4
	19-02	20.4
	20-03	19.6
	21-04	19.3
	22-05	17.4
29 Feb-1 Mar 72	15-22	17.7
	16-23	18.9
	17-24	20.4
	18-01	20.9
	19-02	20.7
	20-03	20.7
	21-04	19.4
	22-05	17.0

* Highest recorded for the period.
** Second highest recorded for the period.

RUNS OF HIGH HOURLY CO CONCENTRATIONS, PITTSBURGH, ZONE 30 (PPM)

DATE	HOURS	8-HOUR AVG. CONCENTRATION
14-15 Dec 71	16-23	18.4
	17-24	19.1
	18-01	19.1
	19-02	18.9
	20-03	18.8
	21-04	18.0
24 Feb 72	11-18	20.0
	12-19	19.5
	13-20	18.9
	14-21	18.8
	15-22	19.0
	16-23	18.9
	17-24	18.4
29 Feb-1 Mar 72	16-23	18.1
	17-24	19.9
	18-01	20.3
	19-02	20.6*
	20-03	19.8
	21-04	18.0

*highest 8-hour average recorded at Bellevue location during the period

APPENDIX C

CITY OF PITTSBURGH   CALENDAR YEAR IS 1972

REGION NO. 5   POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1960 TO 1973

LENGTH OF TIME PERIOD IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.260	24724.85	19622.91	2654.71	2106.91	162.97	129.34	27542.52	21859.16
2	2.070	14729.28	7115.59	1581.47	764.00	102.87	49.69	16413.62	7929.28
3	3.850	22244.99	5777.92	2388.40	620.36	149.75	38.90	24783.13	6437.18
4	2.890	2950.56	1020.96	316.74	109.60	18.53	6.41	3285.84	1136.97
5	5.820	8290.42	1424.47	890.17	152.95	51.35	8.82	9231.93	1586.24
6	4.230	22841.70	5399.93	2452.52	579.79	153.61	36.31	25447.82	6016.03
7	4.540	11431.11	2517.86	1227.37	270.35	71.37	15.72	12729.85	2803.93
8	1.960	2553.17	1302.64	274.08	139.84	15.41	7.86	2842.66	1450.34
9	2.550	13641.27	5349.52	1464.59	574.35	86.62	33.97	15192.48	5957.84
10	6.990	8227.40	1177.02	883.36	126.37	55.27	7.91	9166.03	1311.31
11	1.520	4385.58	2885.25	470.83	309.75	29.37	19.32	4885.77	3214.32
12	3.060	4839.05	1581.39	519.50	169.77	32.86	10.74	5391.41	1761.90
13	2.270	4287.40	1888.72	460.37	202.81	27.55	12.14	4775.32	2103.67
14	3.890	21730.57	5586.27	2333.12	599.77	174.40	44.83	24238.09	6230.87
15	5.510	5367.35	974.11	576.34	104.60	35.71	6.48	5979.40	1085.19
16	1.280	8471.90	6618.67	909.66	710.67	56.90	44.46	9438.46	7373.80
17	1.210	5656.31	4674.64	607.28	501.88	37.33	30.85	6300.92	5207.37
18	2.550	9318.21	3654.20	1000.51	392.36	63.80	25.02	10382.52	4071.58
19	1.850	2234.35	1207.75	239.85	129.65	15.10	8.16	2489.30	1345.57
20	1.690	3015.11	1784.09	298.16	176.43	19.45	11.51	3332.72	1972.03
21	7.170	12857.12	1793.18	724.43	101.04	71.39	9.96	13652.96	1904.18
22	24.780	25607.84	1033.41	1442.95	58.23	151.65	6.12	27202.43	1097.76
23	3.070	7223.39	2352.89	407.04	132.59	41.47	13.51	7671.90	2498.99
24	3.890	3404.93	875.30	194.07	49.89	20.02	5.15	3619.02	930.34
25	9.190	9708.55	1056.43	547.06	59.53	623.69	67.87	10879.29	1183.82
26	12.200	7704.05	631.48	434.13	35.58	46.09	3.78	8184.26	670.84
27	71.500	8235.78	115.19	455.88	6.33	49.50	0.69	8802.22	123.11
28	15.420	2450.41	158.91	138.05	8.95	14.65	0.95	2603.12	168.81
29	9.020	2246.12	249.02	126.59	14.03	13.43	1.49	2386.14	264.54
30	10.340	9666.53	934.87	544.69	52.68	59.62	5.77	10270.83	993.31
31	5.150	4405.74	855.48	248.23	48.20	26.35	5.12	4680.32	908.80
32	93.150	17847.54	191.60	1005.64	10.80	106.75	1.15	18959.94	203.54
33	6.770	3174.11	468.85	178.87	26.42	18.98	2.80	3371.96	498.07
34	10.990	7812.18	710.84	440.19	40.05	46.74	4.25	8299.10	755.15
35	4.790	4998.13	1043.45	281.65	58.80	29.90	6.24	5309.68	1108.49
36	12.820	11203.52	873.91	631.27	49.24	74.03	5.77	11908.81	928.92
37	44.990	6362.34	141.42	358.46	7.97	38.09	0.85	6758.89	150.23
38	38.720	7228.39	186.68	407.29	10.52	43.25	1.12	7678.93	198.32
39	11.300	12621.91	1116.98	711.20	62.94	75.50	6.68	13408.61	1186.60
40	22.870	25170.46	1100.59	1418.32	62.02	152.26	6.66	26741.04	1169.26
41	19.580	6145.77	313.88	346.30	17.69	40.04	2.05	6532.11	333.61
42	13.010	11036.73	848.33	621.87	47.80	66.03	5.08	11724.62	901.20
43	50.620	7793.48	153.96	439.16	8.68	47.88	0.95	8280.52	163.58
44	20.230	27161.34	1342.63	1530.45	75.65	165.84	8.20	28857.63	1426.48
45	34.440	7336.60	213.03	413.42	12.00	43.09	1.25	7793.10	226.28
46	20.510	17628.13	859.49	993.29	48.43	105.78	5.16	18727.20	913.08
47	58.360	14356.13	245.99	808.91	13.86	87.52	1.50	15252.56	261.44
48	8.280	10007.20	1208.60	563.91	68.11	57.11	6.90	10628.21	1283.60
49	11.380	5445.22	478.49	306.85	26.96	30.74	2.70	5782.80	508.15
50	25.780	51059.28	1980.58	2877.06	111.60	306.15	11.88	54242.49	2104.05
51	18.640	8973.43	481.41	505.67	27.13	50.43	2.71	9529.53	511.24
52	25.130	10128.97	403.06	346.22	13.78	38.25	1.52	10513.43	418.36
53	189.390	25018.59	132.10	855.12	4.52	93.68	0.49	25967.38	137.11
54	339.420	17579.57	51.79	600.84	1.77	65.25	0.19	18245.66	53.76
55	239.000	16602.44	69.47	567.48	2.37	64.07	0.27	17233.98	72.11
56	38.230	7296.04	190.85	662.72	17.33	74.29	1.94	8033.05	210.12
57	251.770	14212.66	56.45	1290.99	5.13	144.79	0.58	15648.43	62.15
58	375.250	13503.15	35.98	1226.58	3.27	137.56	0.37	14867.29	39.62
59	91.090	48268.38	529.90	2827.37	31.04	317.52	3.49	51413.26	564.42
60	20.500	5986.45	292.02	350.64	17.10	37.25	1.82	6374.34	310.94
61	17.290	8187.59	473.54	479.55	27.74	53.74	3.11	8720.08	504.39
62	233.970	31577.23	134.96	1849.63	7.91	200.61	0.86	33627.46	143.73
63	513.300	35690.96	69.53	2090.63	4.07	232.18	0.45	38013.77	74.06
64	173.830	27885.47	160.42	1633.45	9.40	203.95	1.17	29722.87	170.99
65	62.340	31097.82	498.84	1336.81	21.44	164.27	2.64	32598.90	522.92
66	344.910	25188.93	73.03	1082.81	3.14	125.45	0.36	26397.21	76.53
67	431.110	31863.85	73.91	1369.78	3.18	167.45	0.39	33401.08	77.48
68	24.480	9482.23	387.35	407.58	16.65	49.35	2.02	9939.16	406.01
69	53.680	17972.72	334.81	1589.36	29.61	170.67	3.18	19732.74	367.60
70	46.990	23067.63	490.91	2039.89	43.41	223.51	4.76	25331.04	539.07
71	243.210	17144.86	70.49	1516.11	6.23	163.16	0.67	18824.13	77.40
72	94.610	6316.43	66.76	558.59	5.90	60.11	0.64	6935.13	73.30

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CITY OF PITTSBURGH CALENDAR YEAR IS 1972
REGION NO. 5 POLLUTANT SPECIES IS HYDROCARBONS
MODEL YEARS CONSIDERED IS FROM 1960 TO 1973
LENGTH OF TIME PI IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		UTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.260	3392.29	2692.30	504.09	400.08	26.81	21.27	3923.19	3113.65
2	2.070	2076.51	1003.14	307.05	148.33	16.92	8.17	2400.48	1159.65
3	3.850	3082.60	800.68	457.26	118.77	24.63	6.40	3564.49	925.84
4	2.890	397.03	137.38	59.25	20.50	3.05	1.05	459.32	158.94
5	5.820	1107.83	190.35	165.55	28.44	8.45	1.45	1281.83	220.24
6	4.230	3162.90	747.73	469.20	110.92	25.26	5.97	3657.36	864.62
7	4.540	1533.56	337.79	229.01	50.44	11.74	2.59	1774.31	390.82
8	1.960	336.93	171.91	50.44	25.74	2.53	1.29	389.91	198.93
9	2.550	1844.87	723.48	275.12	107.89	14.25	5.59	2134.24	836.96
10	6.990	1143.55	163.60	169.77	24.29	9.09	1.30	1322.41	189.19
11	1.520	608.60	400.40	90.37	59.45	4.83	3.18	703.80	463.03
12	3.060	676.35	221.03	100.31	32.78	5.40	1.77	782.06	255.58
13	2.270	583.31	256.96	86.91	38.29	4.53	2.00	674.75	297.25
14	3.890	3288.64	845.41	480.65	123.56	28.69	7.37	3797.97	976.34
15	5.510	742.52	134.76	110.33	20.02	5.87	1.07	858.73	155.85
16	1.280	1177.53	919.95	174.83	136.58	9.36	7.31	1361.72	1063.84
17	1.210	779.48	644.20	115.88	95.77	6.14	5.07	901.49	745.04
18	2.550	1307.67	512.81	193.84	76.02	10.49	4.12	1512.00	592.94
19	1.850	311.54	168.40	46.22	24.98	2.48	1.34	360.25	194.73
20	1.690	410.82	243.09	56.36	33.35	3.20	1.89	470.38	278.33
21	7.170	2234.44	311.64	167.75	23.40	11.74	1.64	2413.94	336.67
22	24.780	4597.20	185.52	342.88	13.84	24.94	1.01	4965.02	200.36
23	3.070	1277.21	416.03	95.56	31.13	6.82	2.22	1379.62	449.39
24	3.890	609.55	156.70	46.03	11.83	3.29	0.85	658.87	169.38
25	9.190	1815.30	197.53	134.21	14.60	102.58	11.16	2052.10	223.30
26	12.200	1392.03	114.10	103.75	8.50	7.58	0.62	1503.36	123.23
27	71.500	1497.14	20.94	111.58	1.56	8.15	0.11	1616.87	22.61
28	15.420	442.76	28.71	32.99	2.14	2.41	0.16	478.16	31.01
29	9.020	405.85	44.99	30.25	3.35	2.21	0.24	438.31	48.59
30	10.340	1768.41	171.03	131.29	12.70	9.81	0.95	1909.50	184.67
31	5.150	796.06	154.58	59.32	11.52	4.33	0.84	859.72	166.94
32	93.150	3224.83	34.62	240.33	2.58	17.56	0.19	3482.72	37.39
33	6.770	573.52	84.72	42.75	6.31	3.12	0.46	619.39	91.49
34	10.990	1411.56	128.44	105.20	9.57	7.69	0.70	1524.45	138.71
35	4.790	903.10	188.54	67.31	14.05	4.92	1.03	975.33	203.62
36	12.820	2124.29	165.70	156.55	12.21	12.18	0.95	2293.02	178.86
37	44.990	1149.60	25.55	85.67	1.90	6.26	0.14	1241.53	27.60
38	38.720	1306.08	33.73	97.33	2.51	7.11	0.18	1410.53	36.43
39	11.300	2280.62	201.83	169.96	15.04	12.42	1.10	2463.01	217.97
40	22.870	4572.18	199.92	340.33	14.88	25.04	1.10	4937.55	215.90
41	19.580	1159.09	59.20	85.58	4.37	6.59	0.34	1251.26	63.91
42	13.010	1994.20	153.28	148.62	11.42	10.86	0.83	2153.68	165.54
43	50.620	1426.87	28.19	106.04	2.09	7.88	0.16	1540.79	30.44
44	20.230	4959.71	245.17	368.86	18.23	27.27	1.35	5355.84	264.75
45	34.460	1314.23	38.16	98.15	2.85	7.09	0.21	1419.47	41.22
46	20.510	3191.16	155.59	237.76	11.59	17.40	0.85	3446.31	168.03
47	58.340	2618.73	44.89	194.77	3.34	14.39	0.25	2827.89	48.47
48	8.280	1768.87	213.63	132.53	16.01	9.39	1.13	1910.79	230.77
49	11.380	957.84	84.17	71.85	6.31	5.06	0.44	1034.74	90.93
50	25.780	9243.66	358.56	688.84	26.72	50.35	1.95	9982.85	387.23
51	18.640	1575.10	84.50	118.21	6.34	8.30	0.45	1701.61	91.29
52	25.130	1889.57	75.19	84.81	3.37	6.29	0.25	1980.67	78.82
53	189.390	4646.86	24.54	208.75	1.10	15.41	0.08	4871.02	25.72
54	339.420	3250.75	9.58	146.17	0.43	10.73	0.03	3407.65	10.04
55	239.000	3131.88	13.10	140.24	0.59	10.54	0.04	3282.66	13.73
56	38.230	1343.69	35.15	160.71	4.20	12.22	0.32	1516.62	39.67
57	251.770	2618.05	10.40	313.11	1.24	23.81	0.09	2954.98	11.74
58	375.250	2487.36	6.63	297.49	0.79	22.63	0.06	2807.47	7.48
59	91.090	9138.89	100.33	700.76	7.69	52.22	0.57	9891.88	108.59
60	20.500	1101.60	53.74	84.98	4.15	6.13	0.30	1192.70	58.18
61	17.290	1549.29	89.55	114.74	6.97	8.84	0.51	1675.87	96.93
62	233.970	5872.52	25.10	451.93	1.93	33.00	0.14	6357.50	27.17
63	513.300	6718.59	13.09	515.80	1.00	38.19	0.07	7272.58	14.17
64	173.830	5585.72	32.13	423.41	2.44	33.55	0.19	6042.68	34.76
65	62.340	5928.04	95.09	333.11	5.34	27.02	0.43	6288.17	100.87
66	344.910	4658.82	13.51	263.46	0.76	20.64	0.06	4942.92	14.33
67	431.110	6057.50	14.05	340.58	0.79	27.54	0.06	6425.63	14.90
68	24.480	1793.51	73.26	100.94	4.12	8.12	0.33	1902.57	77.72
69	53.680	3304.97	61.57	384.95	7.17	28.07	0.52	3717.90	69.26
70	46.990	4285.40	91.20	499.07	10.60	36.77	0.78	4820.24	102.58
71	243.210	3155.90	12.98	367.50	1.51	26.84	0.11	3550.24	14.60
72	94.610	1162.68	12.29	135.40	1.43	9.89	0.10	1307.97	13.82

CITY OF PITTSBURGH CALENDAR YEAR IS 1977

REGION NO. 5 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1955 TO 1978

LENGTH OF TIME PERIOD IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.260	11494.10	9122.30	2157.77	1712.51	177.30	140.72	13829.16	10975.53
2	2.070	6779.83	3275.28	1288.19	622.31	110.44	53.35	8178.45	3950.94
3	3.850	10118.42	2628.16	1907.72	495.51	159.22	41.36	12185.35	3165.03
4	2.890	1331.29	460.66	247.50	85.64	19.63	6.79	1598.43	553.09
5	5.820	3521.21	605.02	652.83	112.17	51.21	8.80	4225.24	725.99
6	4.230	10527.31	2488.73	1986.46	469.14	165.48	39.12	12677.26	2996.99
7	4.540	5213.04	1148.25	968.06	213.23	76.39	16.83	6257.49	1378.30
8	1.960	1180.54	602.32	217.80	111.12	16.74	8.54	1415.08	721.98
9	2.550	6283.28	2464.03	1170.65	459.08	93.56	36.69	7547.49	2959.80
10	6.990	3745.67	535.86	705.88	100.98	58.82	8.42	4510.36	645.26
11	1.520	1913.55	1258.91	360.40	237.10	29.96	19.71	2303.91	1515.73
12	3.060	2042.32	667.43	385.75	126.06	32.41	10.59	2460.48	804.08
13	2.270	1794.22	790.41	335.14	147.64	27.02	11.90	2156.38	949.95
14	3.890	10109.20	2598.51	1980.98	509.25	187.61	48.23	12276.79	3155.99
15	5.510	2272.55	412.44	427.40	77.57	35.37	6.42	2735.32	496.43
16	1.280	4697.62	3670.01	885.29	691.63	73.75	57.63	5656.66	4419.27
17	1.210	2663.40	2201.16	500.15	413.35	41.13	33.99	3204.68	2648.50
18	2.550	4192.75	1644.22	793.37	311.13	67.05	26.29	5053.16	1981.63
19	1.850	886.65	479.27	167.32	90.44	14.00	7.57	1067.97	577.28
20	1.690	1567.59	927.57	293.00	173.38	23.68	14.01	1884.27	1114.95
21	7.170	6593.18	919.55	722.34	100.74	83.11	11.59	7398.63	1031.89
22	24.790	12190.81	491.96	1359.56	54.84	162.97	6.58	13713.34	553.40
23	3.070	3516.56	1145.46	388.77	126.64	45.70	14.89	3951.03	1286.98
24	3.890	1925.15	494.90	214.24	55.07	25.55	6.57	2164.94	556.54
25	9.190	5443.58	592.35	621.41	67.62	78.45	8.53	6143.44	668.49
26	12.200	4177.26	342.40	467.21	38.30	56.35	4.62	4700.82	385.31
27	71.500	4526.21	63.30	506.19	7.08	61.07	0.85	5093.47	71.24
28	15.420	1299.28	84.26	145.31	9.42	17.53	1.14	1462.12	94.82
29	9.020	1144.14	126.85	127.93	14.18	15.43	1.71	1287.50	142.74
30	10.340	5008.98	484.43	560.20	54.18	67.58	6.54	5636.75	545.14
31	5.150	2116.92	411.05	236.74	45.97	28.55	5.54	2382.21	462.56
32	93.150	9837.25	105.61	1100.15	11.81	132.73	1.42	11070.13	118.84
33	6.770	1765.38	260.77	197.43	29.16	23.82	3.52	1986.62	293.45
34	10.990	3653.57	332.44	408.58	37.18	49.29	4.48	4111.44	374.11
35	4.790	2286.01	477.25	255.66	53.37	30.84	6.44	2572.52	537.06
36	12.820	6668.52	520.16	767.58	59.87	98.45	7.68	7534.55	587.72
37	44.990	3783.60	84.10	423.15	9.41	51.05	1.13	4257.80	94.64
38	38.720	3737.41	96.52	417.95	10.79	50.43	1.30	4205.79	108.62
39	11.300	6495.13	574.79	726.36	64.28	87.66	7.76	7309.15	646.83
40	22.870	12490.07	546.13	1401.31	61.27	170.24	7.44	14061.62	614.85
41	19.580	3436.25	175.50	393.91	20.12	50.11	2.56	3880.26	198.18
42	13.010	5705.65	438.56	638.09	49.05	76.99	5.92	6420.72	493.52
43	50.620	4648.64	91.83	523.83	10.35	64.27	1.27	5236.75	103.45
44	20.230	14445.94	714.08	1624.96	80.32	198.55	9.81	16269.43	804.22
45	34.440	3686.70	107.05	410.19	11.91	48.90	1.42	4145.79	120.38
46	20.510	8675.24	422.98	971.12	47.35	117.38	5.72	9763.73	476.05
47	58.340	7273.82	124.68	817.88	14.02	99.83	1.71	8191.52	140.41
48	8.280	4758.07	574.65	525.18	63.43	61.50	7.43	5344.74	645.50
49	11.380	2662.13	233.93	293.03	25.75	34.06	2.99	2989.22	262.67
50	25.780	25453.36	987.33	2848.58	110.50	344.15	13.35	28646.07	1111.17
51	18.640	4269.89	229.07	469.33	25.18	54.41	2.92	4793.63	257.17
52	25.130	4758.34	189.35	328.92	13.09	40.29	1.60	5127.55	204.04
53	189.390	13155.59	69.46	907.05	4.79	110.52	0.58	14173.16	74.84
54	339.420	9096.24	26.80	625.60	1.84	75.82	0.22	9797.66	28.87
55	239.000	8537.97	35.72	593.92	2.49	73.72	0.31	9205.61	38.52
56	38.230	3730.73	97.59	680.30	17.79	85.37	2.23	4496.40	117.61
57	251.770	7679.18	30.50	1400.53	5.56	175.81	0.70	9255.52	36.76
58	375.250	7054.70	18.80	1286.64	3.43	161.50	0.43	8502.84	22.66
59	91.090	25055.23	275.06	2993.23	32.86	368.52	4.05	28417.02	311.97
60	20.500	2858.36	139.43	335.97	16.39	39.96	1.95	3234.29	157.77
61	17.290	3908.63	226.07	465.62	26.93	57.37	3.32	4432.67	256.37
62	233.970	16629.33	71.07	1966.43	8.40	237.00	1.01	18832.76	80.49
63	513.300	19426.69	37.85	2313.22	4.51	282.85	0.55	22022.76	42.90
64	173.830	14593.05	83.95	1800.56	10.36	236.10	1.36	16629.73	95.67
65	62.340	16036.80	259.05	1415.92	22.71	189.77	3.04	17692.45	283.81
66	344.910	14184.44	41.13	1227.13	3.56	158.67	0.46	15570.24	45.14
67	431.110	17111.61	39.69	1503.73	3.49	200.92	0.47	18816.26	43.65
68	24.490	4573.92	186.77	400.78	16.37	53.23	2.17	5027.92	205.39
69	53.550	9092.23	169.38	1512.67	30.06	194.10	3.62	10898.95	203.04
70	46.990	11303.87	240.56	2016.68	42.92	245.78	5.23	13566.32	288.71
71	243.210	9348.30	38.44	1659.11	6.82	199.94	0.82	11207.35	46.08
72	94.610	3195.00	33.77	567.01	5.99	68.33	0.72	3830.34	40.49

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CITY OF PITTSBURGH   CALENDAR YEAR IS 1977

REGION NO. 5   POLLUTANT SPECIES IS HYDROCARBONS

MODEL YEARS CONSIDERED IS FROM 1965 TO 1978

LENGTH OF TIME PERIOD IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.260	1390.03	1103.20	374.68	297.36	29.16	23.14	1793.87	1423.70
2	2.070	838.48	405.06	226.92	109.62	18.15	8.76	1083.57	523.46
3	3.850	1233.90	320.47	333.04	86.50	26.19	6.80	1593.02	413.77
4	2.890	158.52	54.85	42.57	14.73	3.23	1.12	204.32	70.70
5	5.820	416.83	71.62	111.86	19.22	8.42	1.45	537.10	92.28
6	4.230	1282.78	303.26	346.26	81.86	27.22	6.43	1656.26	391.55
7	4.560	619.16	136.33	166.22	36.51	12.59	2.77	797.94	175.76
8	1.960	138.29	70.55	37.05	18.90	2.75	1.40	178.09	90.86
9	2.550	751.34	294.64	201.92	79.19	15.39	6.03	968.66	379.86
10	6.990	458.28	65.56	123.62	17.69	9.67	1.38	591.58	84.63
11	1.520	233.82	153.83	63.06	41.49	4.93	3.24	301.80	198.56
12	3.060	251.05	82.04	67.76	22.15	5.33	1.74	324.14	105.93
13	2.270	215.63	94.99	58.00	25.55	4.44	1.96	278.07	122.50
14	3.890	1325.77	340.81	362.18	93.10	30.85	7.93	1718.80	441.85
15	5.510	276.96	50.26	74.66	13.55	5.82	1.06	357.43	64.87
16	1.280	574.76	449.03	155.04	121.13	12.13	9.48	741.93	579.63
17	1.210	323.54	267.39	87.13	72.05	6.76	5.59	417.46	345.02
18	2.550	517.13	202.80	139.68	54.78	11.03	4.32	667.84	261.90
19	1.850	108.77	58.80	29.35	15.87	2.30	1.24	140.43	75.91
20	1.690	188.62	111.61	50.75	30.03	3.89	2.30	243.27	143.94
21	7.170	968.44	135.07	141.22	19.70	13.67	1.91	1123.33	156.67
22	24.790	1835.92	74.09	269.10	10.86	26.81	1.08	2131.83	86.03
23	3.070	523.53	170.53	76.53	24.93	7.52	2.45	607.58	197.91
24	3.890	289.38	74.39	42.38	10.89	4.20	1.08	335.97	86.37
25	9.190	845.33	91.98	124.75	13.57	12.89	1.40	982.96	106.96
26	12.200	632.45	51.84	92.76	7.60	9.27	0.76	734.49	60.20
27	71.500	685.29	9.58	100.50	1.41	10.06	0.14	795.84	11.13
28	15.420	196.72	12.76	28.85	1.87	2.88	0.19	228.45	14.82
29	9.020	173.23	19.21	25.40	2.82	2.54	0.28	201.17	22.30
30	10.340	758.39	73.35	111.22	10.76	11.12	1.07	880.73	85.18
31	5.150	320.51	62.24	47.00	9.13	4.70	0.91	372.21	72.27
32	93.150	1489.41	15.99	218.43	2.34	21.83	0.23	1729.68	18.57
33	6.770	267.29	39.48	39.20	5.79	3.92	0.58	310.40	45.85
34	10.990	553.17	50.33	81.12	7.38	8.11	0.74	642.40	58.45
35	4.790	346.11	72.26	50.76	10.60	5.07	1.06	401.95	83.91
36	12.820	1046.25	81.61	154.77	12.07	16.19	1.26	1217.21	94.95
37	44.990	572.86	12.73	84.02	1.87	8.40	0.19	665.27	14.79
38	38.720	565.87	14.61	82.98	2.14	8.30	0.21	657.14	16.97
39	11.300	983.40	87.03	144.22	12.76	14.41	1.28	1142.03	101.07
40	22.870	1898.51	83.01	278.71	12.19	28.00	1.22	2205.22	96.42
41	19.580	537.28	27.44	79.36	4.05	8.24	0.42	624.88	31.91
42	13.010	853.87	65.40	126.69	9.74	12.66	0.97	1003.22	77.11
43	50.670	710.84	14.04	104.43	2.06	10.57	0.21	825.89	16.32
44	20.230	2204.96	108.99	323.90	16.01	32.66	1.61	2561.52	126.62
45	34.440	554.62	16.10	81.21	2.36	8.04	0.23	643.88	18.70
46	20.510	1315.46	64.14	192.97	9.41	19.31	0.94	1527.73	74.49
47	58.340	1109.27	19.01	162.94	2.79	16.42	0.28	1288.64	22.09
48	8.290	708.75	85.50	103.62	12.50	10.11	1.22	822.38	99.37
49	11.380	395.12	34.72	57.67	5.07	5.60	0.49	458.38	40.28
50	25.780	3860.36	149.74	566.20	21.96	56.61	2.20	4483.16	173.90
51	18.640	632.74	33.95	92.29	4.95	8.95	0.48	733.98	39.38
52	25.130	737.80	29.36	66.00	2.63	6.63	0.26	810.43	32.25
53	189.390	2033.11	10.74	181.74	0.96	18.18	0.10	2233.03	11.79
54	339.620	1401.09	4.13	125.16	0.37	12.47	0.04	1538.72	4.53
55	239.000	1334.97	5.59	119.63	0.50	12.13	0.05	1466.73	6.14
56	38.230	572.39	14.99	135.91	3.56	14.04	0.37	722.83	18.91
57	251.770	1179.38	4.68	279.81	1.11	28.92	0.11	1488.11	5.91
58	375.250	1083.47	2.89	257.06	0.69	26.56	0.07	1367.10	3.64
59	91.090	3928.45	43.13	603.69	6.63	60.61	0.67	4592.75	50.42
60	20.500	438.65	21.40	67.10	3.27	6.57	0.32	512.32	24.99
61	17.290	612.28	35.41	94.07	5.44	9.44	0.55	715.79	41.40
62	234.070	2572.43	10.99	394.18	1.68	38.99	0.17	3005.60	12.85
63	513.300	3032.71	5.91	465.63	0.91	46.52	0.09	3544.86	6.91
64	173.830	2386.01	13.73	369.97	2.13	39.83	0.22	2795.62	16.08
65	62.360	2535.15	40.57	286.21	4.59	31.21	0.50	2852.59	45.76
66	344.410	2185.15	6.34	245.51	0.71	26.11	0.08	2456.77	7.12
67	431.110	2691.12	6.24	303.69	0.70	33.05	0.08	3027.86	7.02
68	24.480	716.60	29.27	80.66	3.30	8.75	0.36	806.16	32.93
69	53.770	1396.59	25.97	322.61	6.00	31.93	0.59	1751.13	32.57
70	64.370	1745.00	27.11	406.12	6.31	40.67	0.63	2191.79	34.05
71	243.110	1434.96	5.90	331.60	1.36	32.70	0.14	1799.26	7.40
72	94.510	490.41	5.19	113.26	1.20	11.24	0.12	614.91	6.50

CITY OF PITTSBURGH CALENDAR YEAR IS 1972

REGION NO. 5 POLLUTANT SPECIES IS CARBON MONOXIDE

EMISSION INDICES AND TOTAL EMISSIONS BY MODEL YEAR
FOR ZONE NO. 1

VEHICLE CATEGORY -	LIGHT DUTY		HEAVY DUTY	
CALENDAR YEAR	INDEX (GM/MILE)	EMISSIONS (KGM)	INDEX (GM/MILE)	EMISSIONS (KGM)
1960	0.65	8856.07	5.63	2537.48
1961	0.22	3041.48	0.99	447.98
1962	0.40	5380.85	1.18	533.34
1963	0.97	13208.17	2.25	1012.90
1964	2.37	32216.80	2.85	1285.99
1965	2.73	37074.35	4.59	2070.37
1966	4.44	60291.20	5.91	2663.76
1967	5.16	70058.50	8.20	3694.21
1968	5.06	68739.50	8.64	3891.78
1969	4.49	60976.19	11.35	5113.89
1970	4.46	60552.40	12.26	5524.60
1971	7.26	98641.63	13.81	6225.43
1972	1.90	25794.53	7.01	3161.06
1973	0.14	1928.30	0.52	232.14
	40.25	546759.97	85.19	38394.93

40.25 × .8956 + 85.19 × .1044 = 44.97

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           CITY OF PITTSBURGH           CALENDAR YEAR IS 1972

           REGION NO.  5          POLLUTANT SPECIES IS CARBON MONOXIDE

           MODEL YEARS CONSIDERED IS FROM 1966 TO 1973

           LENGTH OF TIME PERIOD IS   24 HOURS

  VEHICLE
  CATEGORY -     LIGHT DUTY            HEAVY DUTY               OTHER                  TOTAL

ZONE  AREA  EMISSIONS    EMISSION    EMISSIONS   EMISSION    EMISSIONS  EMISSION    EMISSIONS   EMISSION
NO.                      DENSITY                 DENSITY                DENSITY                 DENSITY
     (SQ.MI)   (KGM)   (KGM/SQ.MI)   (KGM)    (KGM/SQ.MI)    (KGM)   (KGM/SQ.MI)    (KGM)    (KGM/SQ.MI)

    745.4
 1 ******* 546759.33      733.51    35394.91      51.31     3502.90       4.70    588657.13     789.72
```

$$\frac{603589.96 - 588657.13}{603589.96} = 2.47\%$$

CITY OF PITTSBURGH CALENDAR YEAR IS 1972

REGION NO. 5 POLLUTANT SPECIES IS HYDROCARBONS

EMISSION INDICES AND TOTAL EMISSIONS BY MODEL YEAR
FOR ZONE NO. 1

VEHICLE CATEGORY -	LIGHT DUTY		HEAVY DUTY	
CALENDAR YEAR	INDEX (GM/MILE)	EMISSIONS (KGM)	INDEX (GM/MILE)	EMISSIONS (KGM)
1960	0.17	2276.08	1.41	533.53
1961	0.06	781.66	0.25	111.85
1962	0.10	1382.92	0.30	133.16
1963	0.19	2598.00	0.56	252.89
1964	0.47	6336.93	0.71	321.07
1965	0.54	7292.40	1.15	516.90
1966	0.87	11859.07	1.48	665.05
1967	1.01	13780.26	2.05	922.32
1968	0.70	9561.12	1.67	752.58
1969	0.83	11240.44	2.19	988.91
1970	0.86	11610.34	2.63	1185.40
1971	0.57	7683.39	3.03	1366.58
1972	0.29	3914.64	1.61	723.89
1973	0.02	330.24	0.11	51.19
	6.68	0647.51	19.15	8625.32

6.68 × .8956 + 19.15 × .1044 = 7.98

CITY OF PITTSBURGH CALENDAR YEAR IS 1972

REGION NO. 5 POLLUTANT SPECIES IS HYDROCARBONS

MODEL YEARS CONSIDERED IS FROM 1960 TO 1973

LENGTH OF TIME PERIOD IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	745.400 *******	90647.44	121.61	8525.29	11.57	576.15	0.77	99748.88	133.95

$\frac{102172.92 - 99848.81}{102172.92} = 2.28\%$

CITY OF PITTSBURGH CALENDAR YEAR IS 1977

REGION NO. 5 POLLUTANT SPECIES IS CARBON MONOXIDE

EMISSION INDICES AND TOTAL EMISSIONS BY MODEL YEAR
FOR ZONE NO. 1

VEHICLE CATEGORY -	LIGHT DUTY		HEAVY DUTY	
CALENDAR YEAR	INDEX (GM/MILE)	EMISSIONS (KGM)	INDEX (GM/MILE)	EMISSIONS (KGM)
1965	0.65	10083.14	5.63	2858.33
1966	0.22	3462.90	0.99	504.63
1967	0.40	6126.40	1.18	600.78
1968	0.91	14108.59	2.25	1140.97
1969	1.91	29477.90	2.85	1448.59
1970	1.66	25661.10	4.72	2396.74
1971	3.55	54826.77	5.93	3009.80
1972	1.87	28933.09	7.97	4046.07
1973	2.16	33322.38	8.13	4127.58
1974	2.16	33321.90	5.52	2800.93
1975	0.57	8735.88	9.27	4707.21
1976	0.60	9304.17	10.45	5304.35
1977	0.29	4446.30	5.31	2693.36
1978	0.02	292.70	0.39	197.80
	16.97	262103.22	70.59	35837.14

16.97 × .8956 + 70.59 × .1044 = 22.57

CITY OF PITTSBURGH   CALENDAR YEAR IS 1977

REGION NO. 5   POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1965 TO 1978

LENGTH OF TIME PERIOD IS 24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	745.400 ******	262102.56	351.63	35837.12	48.08	3947.62	5.30	301887.19	405.00

$$\frac{317949.66-301887.19}{317949.66} = 5.05\%$$

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CITY OF PITTSBURGH            CALENDAR YEAR IS 1977

REGION NO.  5           POLLUTANT SPECIES IS HYDRUCARBONS

EMISSIUN INDICES AND TOTAL EMISSIONS BY MODEL YEAR
FUR ZONE NO.    1

VEHICLE
CATEGORY -     LIGHT DUTY               HEAVY DUTY

CALENDAR      INDEX   EMISSIONS        INDEX   EMISSIONS
  YEAR    (GM/MILE)     (KGM)      (GM/MILE)     (KGM)


  1965         0.13    1983.32          1.41      713.63
  1966         0.04     681.14          0.25      125.99
  1967         0.08    1205.04          0.30      149.99
  1968         0.12    1811.41          0.43      220.64
  1969         0.33    5102.71          0.55      280.12
  1970         0.30    4709.11          0.92      466.78
  1971         0.27    4099.64          1.17      592.94
  1972         0.26    3986.59          1.60      811.75
  1973         0.30    4578.42          1.46      739.62
  1974         0.30    4634.70          1.02      517.91
  1975         0.11    1705.45          1.57      794.86
  1976         0.12    1893.83          1.80      914.12
  1977         0.06     983.46          0.95      481.69
  1978         0.00      69.92          0.08       39.56
               2.42   37444.74         13.51     6849.60
```

2.42 × .8956 + 13.51 × .1044 = 3.58

CITY OF PITTSBURGH   CALENDAR YEAR IS 1977

REGION NO. 5   POLLUTANT SPECIES IS HYDROCARBONS

MODEL YEARS CONSIDERED IS FROM 1965 TO 1970

LENGTH OF TIME PERIOD IS   24 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL		
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	
1	745.000 ******	37444.67	50.23	6849.61	9.19	649.30	0.87	44943.57	60.29	$\frac{46935.10 - 44943.57}{46935.10} = 4.24\%$

APPENDIX D

1972 AND 1977 VMT

D-101

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1972

Time Period Peak Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	31	7,044	362	136	
	Arterial	17	5,386	277	104	
	Collector		--	--	--	
	Local	13	29,004	1,491	559	
	TOTAL		41,434	2,130	799	1.26
2	Freeway	31	6,276	323	121	
	Arterial	17	7,583	390	146	
	Collector		--	--	--	
	Local	13	12,290	632	237	
	TOTAL		26,149	1,345	504	2.07
3	Freeway	31	7,234	372	139	
	Arterial	17	8,376	430	161	
	Collector		--	--	--	
	Local	13	22,463	1,154	4	
	TOTAL		38,073	1,956	734	3.85
4	Freeway		0	0	0	
	Arterial	17	2,545	131	49	
	Collector		--	--	--	
	Local	13	2,168	111	42	
	TOTAL		4,713	242	91	2.89
5	Freeway		0	0	0	
	Arterial	17	5,222	268	101	
	Collector		--	--	--	
	Local	13	7,833	403	151	
	TOTAL		13,055	671	252	5.82
6	Freeway	31	7,810	401	151	
	Arterial	17	6,248	321	120	
	Collector		--	--	--	
	Local	13	24,993	1284	482	
	TOTAL		39,051	2,006	753	4.23

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway		0	0	0	
	Arterial	17	8,711	448	168	
	Collector		--	--	--	
	Local	13	9,437	485	182	
	TOTAL		18,148	933	350	4.54
8	Freeway		0	0	0	
	Arterial	17	548	28	11	
	Collector		--	--	--	
	Local	13	3,367	173	65	
	TOTAL		3,915	201	76	1.96
9	Freeway		0	0	0	
	Arterial	17	14,094	724	272	
	Collector		--	--	--	
	Local	13	7,928	407	153	
	TOTAL		22,022	1,131	425	2.55
10	Freeway		0	0	0	
	Arterial	18	6,463	332	125	
	Collector		--	--	--	
	Local	14	7,586	390	146	
	TOTAL		14,049	722	271	6.99
11	Freeway		0	0	0	
	Arterial	18	3,285	169	63	
	Collector		--	--	--	
	Local	14	4,180	215	81	
	TOTAL		7,465	384	144	1.52
12	Freeway		0	0	0	
	Arterial	18	4,429	228	85	
	Collector		--	--	--	
	Local	14	3,928	202	76	
	TOTAL		8,357	430	161	3.06
13	Freeway		0	0	0	
	Arterial	18	1,262	65	24	
	Collector		--	--	--	
	Local	14	5,747	295	110	
	TOTAL		7,009	360	134	2.27

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	31	13,301	684	256	
	Arterial	18	23,498	1,208	453	
	Collector		--	--	--	
	Local	14	7,537	387	145	
	TOTAL		44,336	2,279	854	3.89
15	Freeway		0	0	0	
	Arterial	18	3,632	187	70	
	Collector		--	--	--	
	Local	14	5,447	280	105	
	TOTAL		9,079	467	175	5.51
16	Freeway		0	0	0	
	Arterial	18	6,655	342	128	
	Collector		--	--	--	
	Local	14	7,812	402	151	
	TOTAL		14,467	744	279	1.28
17	Freeway		0	0	0	
	Arterial	18	3,322	171	64	
	Collector		--	--	--	
	Local	14	6,170	317	119	
	TOTAL		9,492	488	183	1.21
18	Freeway		0	0	0	
	Arterial	18	9,409	484	182	
	Collector		--	--	--	
	Local	14	6,813	350	131	
	TOTAL		16,222	834	313	2.55
19	Freeway		0	0	0	
	Arterial	18	1,920	99	37	
	Collector		--	--	--	
	Local	14	1,920	99	37	
	TOTAL		3,840	198	74	1.85
20	Freeway		0	0	0	
	Arterial	18	989	51	19	
	Collector		--	--	--	
	Local	14	3,955	203	76	
	TOTAL		4,944	254	95	1.69

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway		0	0	0	
	Arterial	28	21,918	591	227	
	Collector		--	--	--	
	Local	22	11,802	318	122	
	TOTAL		33,720	909	349	7.17
22	Freeway	36	7,162	193	74	
	Arterial	28	55,151	1,488	572	
	Collector	--	--	--	--	
	Local	22	9,311	251	97	
	TOTAL		71,624	1,932	743	24.78
23	Freeway		0	0	0	
	Arterial	28	15,865	428	165	
	Collector		--	--	--	
	Local	22	3,722	100	39	
	TOTAL		19,587	528	204	3.07
24	Freeway		0	0	0	
	Arterial	28	8,697	235	90	
	Collector		--	--	--	
	Local	22	756	20	8	
	TOTAL		9,453	255	98	3.89
25	Freeway	36	10,898	294	113	
	Arterial	28	14,138	382	147	
	Collector	--	--	--	--	
	Local	28	4,418	119	46	
	TOTAL		29,454	795	306	9.19
26	Freeway		0	0	0	
	Arterial	28	19,155	517	199	
	Collector		--	--	--	
	Local	28	2,612	70	27	
	TOTAL		21,767	587	226	12.20
27	Freeway		0	0	0	
	Arterial	28	22,240	600	231	
	Collector		--	--	--	
	Local	28	1,171	32	12	
	TOTAL		23,411	632	243	71.50

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	28	2,562	69	27	
	Collector		--	--	--	
	Local	28	4,362	118	45	
	TOTAL		6,924	187	72	15.42
29	Freeway		0	0	0	
	Arterial	28	2,983	80	31	
	Collector		--	--	--	
	Local	28	3,363	91	35	
	TOTAL		6,346	171	66	9.02
30	Freeway		0	0	0	
	Arterial	28	27,311	737	283	
	Collector		--	--	--	
	Local	28	845	23	9	
	TOTAL		28,156	760	292	10.34
31	Freeway		0	0	0	
	Arterial	28	9,212	248	96	
	Collector		--	--	--	
	Local	28	3,236	87	34	
	TOTAL		12,448	335	130	5.15
32	Freeway		0	0	0	
	Arterial	28	41,853	1,129	434	
	Collector		--	--	--	
	Local	28	8,572	231	89	
	TOTAL		50,425	1,360	523	93.15
33	Freeway		0	0	0	
	Arterial	28	8,071	218	84	
	Collector		--	--	--	
	Local	28	897	24	9	
	TOTAL		8,968	242	93	6.77
34	Freeway		0	0	0	
	Arterial	28	18,982	512	197	
	Collector		--	--	--	
	Local	28	3,090	83	32	
	TOTAL		22,072	595	229	10.99

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	28	6,920	187	72	
	Collector		--	--	--	
	Local	28	7,202	194	75	
	TOTAL		14,122	381	147	4.79
36	Freeway	36	17,832	481	185	
	Arterial	28	5,594	151	58	
	Collector		--	--	--	
	Local	28	11,538	311	120	
	TOTAL		34,964	943	363	12.82
37	Freeway		0	0	0	
	Arterial	28	13,481	3,733	144	
	Collector		--	--	--	
	Local	28	4,135	112	43	
	TOTAL		17,976	485	187	44.99
38	Freeway		0	0	0	
	Arterial	28	15,930	430	165	
	Collector		--	--	--	
	Local	28	4,493	121	47	
	TOTAL		20,423	551	212	38.72
39	Freeway		0	0	0	
	Arterial	28	31,026	837	322	
	Collector		--	--	--	
	Local	28	4,636	125	48	
	TOTAL		35,662	962	370	11.30
40	Freeway	36	4,315	116	45	
	Arterial	28	58,252	1,571	604	
	Collector		--	--	--	
	Local	28	9,349	252	97	
	TOTAL		71,916	1,939	746	22.87
41	Freeway	44	5,297	143	55	
	Arterial	28	10,026	270	104	
	Collector		--	--	--	
	Local	28	3,594	97	37	
	TOTAL		18,917	510	196	19.58

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
42	Freeway		0	0	0	
	Arterial	28	19,022	513	197	
	Collector		--	--	--	
	Local	28	12,161	328	126	
	TOTAL		31,183	841	323	13.01
43	Freeway	44	2,036	55	21	
	Arterial	28	14,248	384	148	
	Collector		--	--	--	
	Local	28	6,333	171	616	
	TOTAL		22,617	610	235	50.62
44	Freeway	44	13,314	359	138	
	Arterial	28	46,207	1,247	479	
	Collector		--	--	--	
	Local	24	18,796	507	195	
	TOTAL		78,317	2,113	812	20.23
45	Freeway		0	0	0	
	Arterial	28	17,299	467	179	
	Collector		--	--	--	
	Local	24	3,053	82	32	
	TOTAL		20,352	549	211	34.44
46	Freeway	44	3,498	94	36	
	Arterial	28	39,472	1,065	410	
	Collector		--	--	--	
	Local	24	6,996	189	73	
	TOTAL		49,966	1,348	519	20.51
47	Freeway	44	4,546	123	47	
	Arterial	28	32,239	870	334	
	Collector		--	--	--	
	Local	24	4,545	123	47	
	TOTAL		41,331	1,116	428	58.34
48	Freeway		0	0	0	
	Arterial	28	16,453	444	171	
	Collector		--	--	--	
	Local	24	10,520	284	109	
	TOTAL		26,973	728	280	8.28

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	28	7,551	204	78	
	Collector		--	--	--	
	Local	24	6,971	188	72	
	TOTAL		14,522	392	150	11.38
50	Freeway	44	23,136	624	240	
	Arterial	28	69,408	1,872	720	
	Collector		--	--	--	
	Local	24	52,056	1,404	540	
	TOTAL		144,600	3,900	1,500	25.78
51	Freeway		0	0	0	
	Arterial	28	11,435	308	119	
	Collector		--	--	--	
	Local	24	12,387	334	129	
	TOTAL		23,822	642	248	13.64
52	Freeway	50	2,749	45	17	
	Arterial	30	23,522	385	144	
	Collector		--	--	--	
	Local	30	4,277	70	26	
	TOTAL		30,548	500	187	25.13
53	Freeway	50	4,489	73	28	
	Arterial	30	60,597	991	372	
	Collector		--	--	--	
	Local	30	9,725	159	60	
	TOTAL		74,811	1,223	460	189.39
54	Freeway	50	1,563	26	10	
	Arterial	30	43,772	716	269	
	Collector		--	--	--	
	Local	30	6,774	111	42	
	TOTAL		52,109	853	321	339.42
55	Freeway	50	8,187	134	50	
	Arterial	30	37,867	620	232	
	Collector		--	--	--	
	Local	30	5,117	84	31	
	TOTAL		51,171	838	313	239.00

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway		0	0	0	
	Arterial	30	19, 310	840	328	
	Collector		--	--	--	
	Local	30	2, 146	93	37	
	TOTAL		21, 456	933	365	38. 23
57	Freeway		0	0	0	
	Arterial	30	38, 467	1, 673	653	
	Collector		--	--	--	
	Local	30	3, 345	145	57	
	TOTAL		41, 812	1, 818	710	251. 77
58	Freeway		0	0	0	
	Arterial	30	36, 547	1, 589	620	
	Collector		--	--	--	
	Local	30	3, 178	138	54	
	TOTAL		39, 725	1, 727	674	375. 25
59	Freeway	50	28, 466	798	296	
	Arterial	30	92, 889	2, 604	965	
	Collector		--	--	--	
	Local	30	28. 466	798	296	
	TOTAL		149, 821	4, 200	1, 557	91. 09
60	Freeway		0	0	0	
	Arterial	30	14, 410	404	150	
	Collector		--	--	--	
	Local	30	3. 163	89	33	
	TOTAL		17, 573	493	183	20. 50
61	Freeway	50	4, 564	128	47	
	Arterial	30	16, 734	469	174	
	Collector		--	--	--	
	Local	30	4. 057	114	42	
	TOTAL		25, 355	711	263	17. 29
62	Freeway	50	6, 626	186	69	
	Arterial	30	73, 832	2, 070	767	
	Collector		--	--	--	
	Local	30	14, 199	398	147	
	TOTAL		94, 657	2, 654	983	233. 97

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	50	16,433	461	171	
	Arterial	30	76,687	2,150	796	
	Collector		--	--	--	
	Local	30	16,433	461	171	
	TOTAL		109,553	3,072	1,138	513.30
64	Freeway	50	50,046	1,403	520	
	Arterial	30	30,797	864	320	
	Collector		--	--	--	
	Local	30	15,399	432	160	
	TOTAL		96,242	2,699	1,000	173.83
65	Freeway	50	22,494	463	185	
	Arterial	30	60,635	1,248	500	
	Collector		--	--	--	
	Local	30	14,670	302	121	
	TOTAL		97,799	2,013	806	62.34
66	Freeway	50	2,241	46	18	
	Arterial	30	64,241	1,322	529	
	Collector		--	--	--	
	Local	30	8,217	169	68	
	TOTAL		74,699	1,537	615	344.91
67	Freeway	50	20,934	431	173	
	Arterial	30	67,787	1,395	558	
	Collector		--	--	--	
	Local	30	10,966	226	90	
	TOTAL		99,687	2,052	821	431.11
68	Freeway	50	5,288	109	44	
	Arterial	30	19,976	411	164	
	Collector		--	--	--	
	Local	30	4,113	85	34	
	TOTAL		29,377	605	242	24.48
69	Freeway		0	0	0	
	Arterial	30	39,511	1,672	627	
	Collector		--	--	--	
	Local	30	13,170	558	209	
	TOTAL		52,681	2,230	836	53.68

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	50	4,830	204	77	
	Arterial	30	46,918	1,986	745	
	Collector		--	--	--	
	Local	30	17,249	730	274	
	TOTAL		68,997	2,920	1,096	46.99
71	Freeway		0	0	0	
	Arterial	30	42,808	1,812	680	
	Collector		--	--	--	
	Local	30	7,554	320	120	
	TOTAL		50,362	2,132	800	243.21
72	Freeway		0	0	0	
	Arterial	30	15,771	668	251	
	Collector		--	--	--	
	Local	30	2,783	118	44	
	TOTAL		18,554	786	295	94.61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total for All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		2,654,827	81,069	30,833	2,766,729

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1972

Time Period 12 hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	39	52,828	2,715	1,018	
	Arterial	19	40,398	2,076	779	
	Collector		--	--	--	
	Local	17	217,527	11,179	4193	
	TOTAL		310,753	15,970	5,990	1.26
2	Freeway	39	47,069	2,419	907	
	Arterial	19	56,876	2,923	1,096	
	Collector		--	--	--	
	Local	17	92,178	4739	1,777	
	TOTAL		196,123	10,081	3,780	2.07
3	Freeway	39	54,253	2,789	1,046	
	Arterial	19	62,819	3,228	1,211	
	Collector	--	--	--	--	
	Local	17	168,469	8,658	3,247	
	TOTAL		285,541	14,675	5,504	3.85
4	Freeway		0	0	0	
	Arterial	19	19,090	981	368	
	Collector	--	--	--	--	
	Local	17	16,262	836	314	
	TOTAL		35,352	1,817	682	2.89
5	Freeway		0	0	0	
	Arterial	19	39,161	2,012	755	
	Collector		--	--	--	
	Local	17	58,744	3,019	1,132	
	TOTAL		97,905	5,031	1,887	5.82
6	Freeway	39	58,578	3,011	1,129	
	Arterial	19	46,862	2,408	903	
	Collector		--	--	--	
	Local	17	187,450	9,633	3,613	
	TOTAL		292,890	15,052	5,645	4.23

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway	19	0	0	0	
	Arterial		65,333	3,358	1,259	
	Collector		--	--	--	
	Local	17	70778	3,638	1,364	
	TOTAL		136,111	6,996	2623	4.54
8	Freeway	19	0	0	0	
	Arterial		4,112	212	80	
	Collector		--	--	--	
	Local	17	25,256	1,298	487	
	TOTAL		29,368	1,510	567	1.96
9	Freeway	19	0	0	0	
	Arterial		105,703	5,432	2,037	
	Collector		--	--	--	
	Local	17	59,459	3,056	1,146	
	TOTAL		165,162	8488	3183	2.55
10	Freeway	22	0	0	0	
	Arterial		48,469	2,492	934	
	Collector		--	--	--	
	Local	18	56,898	2,924	1097	
	TOTAL		105,367	5,416	2,031	6.99
11	Freeway	22	0	0	0	
	Arterial		24,635	1,266	475	
	Collector		--	--	--	
	Local	18	31,352	1,611	605	
	TOTAL		55,987	2,877	1,080	1.52
12	Freeway	22	0	0	0	
	Arterial		33,216	1,707	641	
	Collector		--	--	--	
	Local	18	29,456	1,514	568	
	TOTAL		62,672	3,221	1,209	3.06
13	Freeway	22	0	0	0	
	Arterial		9462	486	182	
	Collector		--	--	--	
	Local	18	43,100	2,215	832	
	TOTAL		52,562	2,701	1,014	2.27

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	39	99,758	5,127	1922	
	Arterial	22	176,238	9,057	3,397	
	Collector		--	--	--	
	Local	18	56,528	2,906	1,090	
	TOTAL		332,524	17,090	6,409	3.89
15	Freeway		0	0	0	
	Arterial	22	27,235	1,400	525	
	Collector		--	--	--	
	Local	18	40,853	2,099	788	
	TOTAL		68,088	3,499	1,313	5.51
16	Freeway		0	0	0	
	Arterial	22	49,910	2,565	962	
	Collector		--	--	--	
	Local	18	58,589	3,011	1,130	
	TOTAL		108,499	5576	2092	1.28
17	Freeway		0	0	0	
	Arterial	22	24,917	1,280	480	
	Collector		--	--	--	
	Local	18	46,274	2,379	892	
	TOTAL		71,191	3,659	1,372	1.21
18	Freeway		0	0	0	
	Arterial	22	70,565	3,626	1,360	
	Collector		--	--	--	
	Local	18	51,099	2,627	985	
	TOTAL		121,664	6,253	2,345	2.55
19	Freeway		0	0	0	
	Arterial	22	14,399	740	278	
	Collector		--	--	--	
	Local	18	14,399	740	278	
	TOTAL		28,798	1,480	556	1.85
20	Freeway		0	0	0	
	Arterial	22	7417	381	143	
	Collector		--	--	--	
	Local	18	29,661	1,524	572	
	TOTAL		37,078	1,905	715	1.69

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
21	Freeway		0	0	0	
	Arterial	36	164, 381	4,433	1,705	
	Collector		--	--	--	
	Local	28	88, 514	2,387	918	
	TOTAL		252, 895	6,820	2,623	7. 17
22	Freeway	45	53, 718	1,449	557	
	Arterial	36	413, 632	11,156	4,291	
	Collector		--	--	--	
	Local	28	69, 835	1,883	725	
	TOTAL		537, 185	14,488	5,573	24.78
23	Freeway		0	0	0	
	Arterial	36	118, 989	3,209	1235	
	Collector		--	--	--	
	Local	28	27, 911	753	290	
	TOTAL		146, 900	3,962	1,525	3. 07
24	Freeway		0	0	0	
	Arterial	36	65, 226	1,760	677	
	Collector		--	--	--	
	Local	28	5, 673	153	59	
	TOTAL		70, 899	1,913	736	3. 89
25	Freeway	45	81, 734	2,204	848	
	Arterial	36	106, 033	2,860	1,100	
	Collector		--	--	--	
	Local	36	33, 135	894	344	
	TOTAL		220, 902	5,958	2,292	9. 19
26	Freeway		0	0	0	
	Arterial	36	143, 660	3,875	1,490	
	Collector		--	--	--	
	Local	36	19, 591	528	203	
	TOTAL		163, 251	4,403	1,693	12. 20
27	Freeway		0	0	0	
	Arterial	36	165, 798	4,499	1,730	
	Collector		--	--	--	
	Local	36	8, 779	237	92	
	TOTAL		175, 577	4,736	1,822	71. 50

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	36	19,212	518	200	
	Collector		--	--	--	
	Local	36	32,713	882	339	
	TOTAL		51,925	1,400	539	15.42
29	Freeway		0	0	0	
	Arterial	36	22,371	603	232	
	Collector		--	--	--	
	Local	36	25,226	680	262	
	TOTAL		47,597	1,283	494	9.02
30	Freeway		0	0	0	
	Arterial	36	204,836	5,525	2,125	
	Collector		--	--	--	
	Local	36	6335	171	66	
	TOTAL		211,171	5696	2191	10.34
31	Freeway		0	0	0	
	Arterial	36	69,086	1,863	716	
	Collector		--	--	--	
	Local	36	24,273	655	252	
	TOTAL		93,359	2,518	968	5.15
32	Freeway		0	0	0	
	Arterial	36	313,900	8,466	3,257	
	Collector		--	--	--	
	Local	36	64,293	1,734	667	
	TOTAL		378,193	10,200	3,924	93.15
33	Freeway		0	0	0	
	Arterial	36	60,534	1,633	628	
	Collector		--	--	--	
	Local	36	6726	182	70	
	TOTAL		67,260	1,815	698	6.77
34	Freeway		0	0	0	
	Arterial	36	142,367	3,840	1,477	
	Collector		--	--	--	
	Local	36	23,176	625	240	
	TOTAL		165,543	4,465	1,717	10.99

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	36	51,897	1,400	539	
	Collector		--	--	--	
	Local	36	54,015	1,457	560	
	TOTAL		105,912	2,857	1,099	4.79
36	Freeway	45	133,741	3,607	1388	
	Arterial	36	41,958	1,132	435	
	Collector		--	--	--	
	Local	36	86,537	2,334	898	
	TOTAL		262,236	7,073	2,721	12.82
37	Freeway		0	0	0	
	Arterial	36	103,811	2,800	1,077	
	Collector		--	--	--	
	Local	36	31,009	836	322	
	TOTAL		134,820	3,636	1,399	44.99
38	Freeway		0	0	0	
	Arterial	36	119,474	3,222	1,239	
	Collector		--	--	--	
	Local	36	33,698	909	350	
	TOTAL		153,172	4,131	1,589	38.72
39	Freeway		0	0	0	
	Arterial	36	232,691	6276	2,414	
	Collector		--	--	--	
	Local	36	34,770	938	361	
	TOTAL		267,461	7,214	2,775	11.30
40	Freeway	45	32,363	873	336	
	Arterial	36	436,893	11,783	4,532	
	Collector		--	--	--	
	Local	36	70,119	1,892	728	
	TOTAL		539,375	14,548	5,596	22.87
41	Freeway	54	39,725	1,072	413	
	Arterial	36	75,194	2,028	780	
	Collector		--	--	--	
	Local	36	26,957	727	280	
	TOTAL		141,876	3,827	1,473	19.58

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
42	Freeway		0	0	0	
	Arterial	36	142, 661	3,848	1,480	
	Collector		--	--	--	
	Local	36	91, 209	2,460	947	
	TOTAL		233, 870	6,308	2427	13. 01
43	Freeway	54	15, 266	412	158	
	Arterial	36	106, 861	2,882	1,109	
	Collector		--	--	--	
	Local	36	47, 494	1,281	493	
	TOTAL		169, 621	4,575	1,760	50. 62
44	Freeway	54	99, 854	2,693	1,036	
	Arterial	36	346, 553	9,347	3,595	
	Collector		--	--	--	
	Local	30	140, 971	3,802	1,463	
	TOTAL		587, 378	15,842	6,094	20. 23
45	Freeway		0	0	0	
	Arterial	36	129, 737	3,499	1,346	
	Collector		--	--	--	
	Local	30	22, 895	617	238	
	TOTAL		152, 632	4,116	1,584	34. 44
46	Freeway	54	26, 232	707	272	
	Arterial	36	296, 043	7,985	3,071	
	Collector		--	--	--	
	Local	30	52, 464	1,415	545	
	TOTAL		374, 739	10,107	3,888	20. 51
47	Freeway	54	34, 098	920	354	
	Arterial	36	241, 789	6,521	2,508	
	Collector		--	--	--	
	Local	30	34, 098	920	354	
	TOTAL		309, 985	8,361	3,216	58. 34
48	Freeway		0	0	0	
	Arterial	36	123, 397	3,328	1,280	
	Collector		--	--	--	
	Local	30	78, 893	2,128	818	
	TOTAL		202, 290	5,456	2,098	8. 28

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	36	56,636	1,528	587	
	Collector		--	--	--	
	Local	30	52,279	1,410	542	
	TOTAL		108,915	2,938	1,129	11.38
50	Freeway	54	173,520	4,680	1,800	
	Arterial	36	520,559	14,040	5,400	
	Collector		--	--	--	
	Local	30	390,420	10,530	4,050	
	TOTAL		1,084,499	29,250	11,250	25.78
51	Freeway		0	0	0	
	Arterial	36	85,760	2,313	890	
	Collector		--	--	--	
	Local	30	92,906	2,506	964	
	TOTAL		178,666	4819	1854	13.64
52	Freeway	56	20,621	338	127	
	Arterial	38	176,417	2,886	1,082	
	Collector		--	--	--	
	Local	37	32,076	525	197	
	TOTAL		229,114	3749	1,406	25.13
53	Freeway	56	33,665	551	206	
	Arterial	38	454,474	7,436	2,789	
	Collector		--	--	--	
	Local	37	72,940	1,193	448	
	TOTAL		561,079	9180	3443	189.39
54	Freeway	56	11,725	192	72	
	Arterial	38	328,293	5,371	2,014	
	Collector		--	--	--	
	Local	37	50,807	831	312	
	TOTAL		390,825	6394	2398	339.42
55	Freeway	56	61,406	1,004	377	
	Arterial	38	284,003	4,646	1,742	
	Collector		--	--	--	
	Local	37	38,379	628	236	
	TOTAL		383,788	6,278	2,355	239.00

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway	-	0	0	0	
	Arterial	38	144,821	6,296	2,457	
	Collector		--	--	--	
	Local	37	16,091	700	273	
	TOTAL		160,912	6,996	2,730	38.23
57	Freeway		0	0	0	
	Arterial	38	288,503	12,544	4,895	
	Collector		--	--	--	
	Local	37	25,087	1,091	425	
	TOTAL		313,590	13,635	5,320	251.77
58	Freeway		0	0	0	
	Arterial	38	274,100	11,918	4,651	
	Collector		--	--	--	
	Local	37	23,835	1,037	404	
	TOTAL		297,935	12,955	5,055	375.25
59	Freeway	56	213,494	5,986	2,217	
	Arterial	38	696,665	19,532	7,235	
	Collector		--	--	--	
	Local	37	213,494	5,986	2,217	
	TOTAL		1123,653	31,504	11,669	91.09
60	Freeway		0	0	0	
	Arterial	38	108,078	3,030	1,122	
	Collector		--	--	--	
	Local	37	23,725	665	247	
	TOTAL		131,803	3,695	1,369	20.50
61	Freeway	56	34,228	960	356	
	Arterial	38	125,501	3,519	1,304	
	Collector		--	--	--	
	Local	37	30,425	853	316	
	TOTAL		190,154	5,332	1,976	17.29
62	Freeway	56	49,695	1,394	516	
	Arterial	38	553,742	15,526	5,750	
	Collector		--	--	--	
	Local	37	106,490	2,986	1,106	
	TOTAL		709,927	19,906	7,372	233.97

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	56	123,247	3,455	1,280	
	Arterial	38	575,154	16,126	5,972	
	Collector		--	--	--	
	Local	37	123,247	3,455	1,280	
	TOTAL		821,648	23,036	8,532	513.30
64	Freeway	56	375,343	10,523	3,898	
	Arterial	38	230,980	6,476	2,399	
	Collector		--	--	--	
	Local	37	115,490	3,238	1,199	
	TOTAL		721,813	20,237	7,496	173.83
65	Freeway	56	168,702	3,471	1,388	
	Arterial	38	454,765	9,357	3,743	
	Collector		--	--	--	
	Local	37	110,024	2,264	905	
	TOTAL		733,491	15,092	6,036	62.34
66	Freeway	56	16,807	346	138	
	Arterial	38	481,805	9,914	3,966	
	Collector		--	--	--	
	Local	37	61,626	1,268	507	
	TOTAL		560,238	11,528	4,611	344.91
67	Freeway	56	157,007	3,230	1,292	
	Arterial	38	508,406	10,461	4,184	
	Collector		--	--	--	
	Local	37	82,242	1,692	676	
	TOTAL		747,655	15,383	6,152	431.11
68	Freeway	56	39,658	816	326	
	Arterial	38	149,820	3,083	1,233	
	Collector		--	--	--	
	Local	37	30,845	635	254	
	TOTAL		220,323	4,534	1,813	24.48
69	Freeway		0	0	0	
	Arterial	38	296,333	12,543	4,704	
	Collector		--	--	--	
	Local	37	98,777	4,181	1,568	
	TOTAL		395,110	16,724	6,272	53.68

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	56	36,224	1,533	575	
	Arterial	38	351,887	14,895	5,586	
	Collector		--	--	--	
	Local	37	129,370	5,476	2,054	
	TOTAL		517,481	21,904	8,215	46.99
71	Freeway		0	0	0	
	Arterial	38	321,061	13,590	5,096	
	Collector		--	--	--	
	Local	37	56,658	2,399	899	
	TOTAL		377,719	15,989	5,995	243.21
72	Freeway		0	0	0	
	Arterial	38	118,284	5,007	1,878	
	Collector		--	--	--	
	Local	37	20,873	884	332	
	TOTAL		139,157	5,891	2,210	94.61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total for All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		19,911,154	607,954	231,169	20,750,277

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1972

Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	39	70,437	3,620	1,357	
	Arterial	19	53,864	2,768	1,038	
	Collector		--	--	--	
	Local	17	290,036	14,905	5,590	
	TOTAL		414,337	21,293	7,985	1.26
2	Freeway	39	62,759	3,225	1,209	
	Arterial	19	75,834	3,897	1,461	
	Collector		--	--	--	
	Local	17	122,904	6,316	2,369	
	TOTAL		261,497	13,438	5,039	2.07
3	Freeway	39	72,337	3,718	1,394	
	Arterial	19	83,758	4,304	1,614	
	Collector		--	--	--	
	Local	17	224,625	11,544	4,329	
	TOTAL		380,720	19,566	7,337	3.85
4	Freeway		0	0	0	
	Arterial	19	25,453	1,308	491	
	Collector		--	--	--	
	Local	17	21,683	1,114	418	
	TOTAL		47,136	2,422	909	2.89
5	Freeway		0	0	0	
	Arterial	19	52,215	2,683	1,006	
	Collector		--	--	--	
	Local	17	78,325	4,025	1,509	
	TOTAL		130,540	6,708	2,515	5.82
6	Freeway	39	78,104	4,014	1,505	
	Arterial	19	62,483	3,211	1,204	
	Collector		--	--	--	
	Local	17	249,933	12,844	4,817	
	TOTAL		390,520	20,069	7,526	4.23

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway		0	0	0	
	Arterial	19	87,110	4,477	1,679	
	Collector		--	--	--	
	Local	17	94,370	4,850	1,819	
	TOTAL		181,480	9,327	3,498	4.54
8	Freeway		0	0	0	
	Arterial	19	5,482	282	106	
	Collector		--	--	--	
	Local	17	33,674	1,731	649	
	TOTAL		39,156	2,013	755	1.96
9	Freeway		0	0	0	
	Arterial	19	140,937	7,243	2,716	
	Collector		--	--	--	
	Local	17	79,278	4,074	1,528	
	TOTAL		220,215	11,317	4,244	2.55
10	Freeway		0	0	0	
	Arterial	22	64,625	3,322	1,245	
	Collector		--	--	--	
	Local	18	75,864	3,899	1,462	
	TOTAL		140,489	7,221	2,707	6.99
11	Freeway		0	0	0	
	Arterial	22	32,846	1,688	633	
	Collector		--	--	--	
	Local	18	41,803	2,148	806	
	TOTAL		74,649	3,836	1,439	1.52
12	Freeway		0	0	0	
	Arterial	22	44,288	2,276	854	
	Collector		--	--	--	
	Local	18	39,275	2,018	757	
	TOTAL		83,563	4,294	1,611	3.06
13	Freeway		0	0	0	
	Arterial	22	12,615	648	243	
	Collector		--	--	--	
	Local	18	57,467	2.953	1,108	
	TOTAL		70,082	3,601	1,351	2.27

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	39	133,010	6,836	2,563	
	Arterial	22	234,984	12,076	4,529	
	Collector		--	--	--	
	Local	18	75,371	3,874	1,453	
	TOTAL		443,365	22,786	8,545	3.89
15	Freeway		0	0	0	
	Arterial	22	36,313	1,866	700	
	Collector		--	--	--	
	Local	18	54,470	2,799	1,050	
	TOTAL		90,783	4,665	1,750	5.51
16	Freeway		0	0	0	
	Arterial	22	66,546	3,420	1,282	
	Collector		--	--	--	
	Local	18	78,118	4,015	1,506	
	TOTAL		144,664	7,435	2,788	1.28
17	Freeway		0	0	0	
	Arterial	22	33,222	1,707	640	
	Collector		--	--	--	
	Local	18	61,699	3,172	1,189	
	TOTAL		94,921	4,879	1,829	1.21
18	Freeway		0	0	0	
	Arterial	22	94,087	4,835	1,813	
	Collector		--	--	--	
	Local	18	68,132	3,502	1,313	
	TOTAL		162,219	8,337	3,126	2.55
19	Freeway		0	0	0	
	Arterial	22	19,198	987	370	
	Collector		--	--	--	
	Local	18	19,199	987	370	
	TOTAL		38,397	1,974	740	1.85
20	Freeway		0	0	0	
	Arterial	22	9,889	508	190	
	Collector		--	--	--	
	Local	18	39,548	2,032	762	
	TOTAL		49,437	2,540	952	1.69

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway		0	0	0	
	Arterial	36	219,175	5,911	2,273	
	Collector		--	--	--	
	Local	28	118,019	3,183	1,224	
	TOTAL		337,194	9,004	3,497	7.17
22	Freeway	45	71,624	1,932	743	
	Arterial	36	551,509	14,875	5,721	
	Collector		--	--	--	
	Local	28	93,113	2,511	966	
	TOTAL		716,246	19,318	7,430	24.78
23	Freeway		0	0	0	
	Arterial	36	158,652	4,279	1,646	
	Collector		--	--	--	
	Local	28	37,215	1,004	386	
	TOTAL		195,867	5,283	2,032	3.07
24	Freeway		0	0	0	
	Arterial	36	86,968	2,346	902	
	Collector		--	--	--	
	Local	28	7,563	204	78	
	TOTAL		94,531	2,550	980	3.89
25	Freeway	45	108,978	2,939	1,130	
	Arterial	36	141,377	3,813	1,467	
	Collector		--	--	--	
	Local	36	44,180	1,192	458	
	TOTAL		294,535	7,944	3,055	9.19
26	Freeway		0	0	0	
	Arterial	36	191,547	5,166	1,987	
	Collector		--	--	--	
	Local	36	26,121	704	271	
	TOTAL		217,668	5,870	2,258	12.20
27	Freeway		0	0	0	
	Arterial	36	222,397	5,998	2,307	
	Collector		--	--	--	
	Local	36	11,705	316	122	
	TOTAL		234,102	6,314	2,429	71.50

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	36	25,616	691	266	
	Collector		--	--	--	
	Local	36	43,617	1,176	452	
	TOTAL		69,233	1,867	718	15.42
29	Freeway		0	0	0	
	Arterial	36	29,828	804	309	
	Collector		--	--	--	
	Local	36	33,634	907	349	
	TOTAL		63,462	1,711	658	9.02
30	Freeway		0	0	0	
	Arterial	36	273,114	7,366	2,833	
	Collector		--	--	--	
	Local	36	8,447	228	88	
	TOTAL		281,561	7,594	2,921	10.34
31	Freeway		0	0	0	
	Arterial	36	92,115	2,484	955	
	Collector		--	--	--	
	Local	36	32,364	873	336	
	TOTAL		124,479	3,357	1,291	5.15
32	Freeway		0	0	0	
	Arterial	36	418,533	11,288	4,342	
	Collector		--	--	--	
	Local	36	85,724	2,312	889	
	TOTAL		504,257	13,600	5,231	93.15
33	Freeway		0	0	0	
	Arterial	36	80,712	2,177	837	
	Collector		--	--	--	
	Local	36	8,968	242	93	
	TOTAL		89,680	2,419	930	6.77
34	Freeway		0	0	0	
	Arterial	36	189,822	5,120	1,969	
	Collector		--	--	--	
	Local	36	30,901	833	320	
	TOTAL		220,723	5,953	2,289	10.99

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	36	69,196	1,866	718	
	Collector		--	--	--	
	Local	36	72,020	1,942	747	
	TOTAL		141,216	3,808	1,465	4.79
36	Freeway	45	178,321	4,809	1,850	
	Arterial	36	55,944	1,509	580	
	Collector		--	--	--	
	Local	36	115,383	3,112	1,197	
	TOTAL		349,648	9,430	3,627	12.82
37	Freeway		0	0	0	
	Arterial	36	138,414	3,733	1,436	
	Collector		--	--	--	
	Local	36	41,345	1,115	429	
	TOTAL		179,759	4,848	1,865	44.99
38	Freeway		0	0	0	
	Arterial	36	159,299	4,296	1,652	
	Collector		--	--	--	
	Local	36	44,930	1,212	466	
	TOTAL		204,229	5,508	2,118	38.72
39	Freeway		0	0	0	
	Arterial	36	310,255	8,368	3,218	
	Collector		--	--	--	
	Local	36	46,360	1,250	481	
	TOTAL		356,615	9,618	3,699	11.30
40	Freeway	45	43,151	1,164	448	
	Arterial	36	582,524	15,711	6,043	
	Collector		--	--	--	
	Local	36	93,492	2,522	970	
	TOTAL		719,167	19,397	7,461	22.87
41	Freeway	54	52,967	1,429	550	
	Arterial	36	100,258	2,704	1,040	
	Collector		--	--	--	
	Local	36	35,942	969	373	
	TOTAL		189,167	5,102	1,963	19.58

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
42	Freeway		0	0	0	
	Arterial	36	190,215	5,130	1,973	
	Collector		--	--	--	
	Local	36	121,612	3,280	1,262	
	TOTAL		311,827	8,410	3,235	13.01
43	Freeway	54	20,355	549	211	
	Arterial	36	142,481	3,843	1,478	
	Collector		--	--	--	
	Local	36	63,325	1,708	657	
	TOTAL		226,161	6,100	2,346	50.62
44	Freeway	54	133,139	3,591	1,381	
	Arterial	36	462,071	12,463	4,793	
	Collector		--	--	--	
	Local	30	187,961	5,069	1,950	
	TOTAL		783,171	21,123	8,124	20.23
45	Freeway		0	0	0	
	Arterial	36	172,982	4,665	1,794	
	Collector		--	--	--	
	Local	30	30,526	823	317	
	TOTAL		203,508	5,488	2,111	34.44
46	Freeway	54	34,976	943	363	
	Arterial	36	394,724	10,646	4,095	
	Collector		--	--	--	
	Local	30	69,952	1,887	726	
	TOTAL		499,652	13,476	5,184	20.51
47	Freeway	54	45,464	1,226	472	
	Arterial	36	322,385	8,695	3,344	
	Collector		--	--	--	
	Local	30	45,464	1,226	472	
	TOTAL		413,313	11,147	4,288	58.34
48	Freeway		0	0	0	
	Arterial	36	164,529	4,437	1,707	
	Collector		--	--	--	
	Local	30	105,191	2,837	1,091	
	TOTAL		269,720	7,274	2,798	8.28

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	36	75,514	2,037	783	
	Collector		--	--	--	
	Local	30	69,705	1,880	723	
	TOTAL		145,219	3,917	1,506	11.38
50	Freeway	54	231,360	6,240	2,400	
	Arterial	36	694,079	18,720	7,200	
	Collector		--	--	--	
	Local	30	520,560	14,040	5,400	
	TOTAL		1,445,999	39,000	15,000	25.78
51	Freeway		0	0	0	
	Arterial	36	114,346	3,084	1,186	
	Collector		--	--	--	
	Local	30	123,874	3,341	1,285	
	TOTAL		238,220	6,425	2,471	13.64
52	Freeway	56	27,494	450	169	
	Arterial	38	235,222	3,848	1,443	
	Collector		--	--	--	
	Local	37	42,768	700	262	
	TOTAL		305,484	4,998	1,874	25.13
53	Freeway	56	44,886	734	275	
	Arterial	38	605,965	9,914	3,718	
	Collector		--	--	--	
	Local	37	97,253	1,591	597	
	TOTAL		748,104	12,239	4,590	189.39
54	Freeway	56	15,633	256	96	
	Arterial	38	437,724	7,161	2,685	
	Collector		--	--	--	
	Local	37	67,743	1,108	416	
	TOTAL		521,100	8,525	3,197	339.42
55	Freeway	56	81,874	1,339	502	
	Arterial	38	378,671	6,195	2,323	
	Collector		--	--	--	
	Local	37	51,172	837	314	
	TOTAL		511,717	8,371	3,139	239.00

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway		0	0	0	
	Arterial	38	193,095	8,395	3,276	
	Collector		--	--	--	
	Local	37	21,455	933	364	
	TOTAL		214,550	9,328	3,640	38.23
57	Freeway		0	0	0	
	Arterial	38	384,671	16,725	6,527	
	Collector		--	--	--	
	Local	37	33,449	1,454	567	
	TOTAL		418,120	18,179	7,094	251.77
58	Freeway		0	0	0	
	Arterial	38	365,467	15,890	6,201	
	Collector		--	--	--	
	Local	37	31,780	1,382	539	
	TOTAL		397,247	17,272	6,740	375.25
59	Freeway	56	284,658	7,981	2,956	
	Arterial	38	928,886	26,043	9,646	
	Collector		--	--	--	
	Local	37	284,659	7,981	2,956	
	TOTAL		1,498,203	42,005	15,558	91.09
60	Freeway		0	0	0	
	Arterial	38	144,104	4,040	1,496	
	Collector		--	--	--	
	Local	37	31,633	887	329	
	TOTAL		175,737	4,927	1,825	20.50
61	Freeway	56	45,637	1,280	474	
	Arterial	38	167,335	4,692	1,738	
	Collector		--	--	--	
	Local	37	40,566	1,137	421	
	TOTAL		253,538	7,109	2,633	17.29
62	Freeway	56	66,260	1,858	688	
	Arterial	38	738,323	20,701	7,667	
	Collector		--	--	--	
	Local	37	141,986	3,981	1,474	
	TOTAL		946,569	26,540	9,829	233.97

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	56	164,329	4,607	1,706	
	Arterial	38	766,872	21,501	7,963	
	Collector		--	--	--	
	Local	37	164,329	4,607	1,706	
	TOTAL		1,095,530	30,715	11,375	513.30
64	Freeway	56	500,457	14,031	5,197	
	Arterial	38	307,973	8,635	3,198	
	Collector		--	--	--	
	Local	37	153,987	4,317	1,599	
	TOTAL		962,417	26,983	9,994	173.83
65	Freeway	56	224,936	4,628	1,851	
	Arterial	38	606,353	12,476	4,990	
	Collector		--	--	--	
	Local	37	146,698	3,018	1,207	
	TOTAL		977,987	20,122	8,048	62.34
66	Freeway	56	22,409	461	184	
	Arterial	38	642,407	13,218	5,287	
	Collector		--	--	--	
	Local	37	82,168	1,691	676	
	TOTAL		746,984	15,370	6,147	344.91
67	Freeway	56	209,343	4,307	1,723	
	Arterial	38	677,874	13,948	5,579	
	Collector		--	--	--	
	Local	37	109,656	2,256	902	
	TOTAL		996,873	20,511	8,204	431.11
68	Freeway	56	52,877	1,088	435	
	Arterial	38	199,760	4,110	1,644	
	Collector		--	--	--	
	Local	37	41,126	846	338	
	TOTAL		293,763	6,044	2,417	24.48
69	Freeway		0	0	0	
	Arterial	38	395,110	16,724	6,272	
	Collector		--	--	--	
	Local	37	131,702	5,575	2,091	
	TOTAL		526,812	22,299	8,363	53.68

Pittsburgh - 1972 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	56	48,298	2,044	766	
	Arterial	38	469,182	19,860	7,448	
	Collector		--	--	--	
	Local	37	172,493	7,301	2,738	
	TOTAL		689,973	29,205	10,952	46.99
71	Freeway		0	0	0	
	Arterial	38	428,081	18,120	6,795	
	Collector		--	--	--	
	Local	37	75,544	3,198	1,199	
	TOTAL		503,625	21,318	7,994	243.21
72	Freeway		0	0	0	
	Arterial	38	157,712	6,676	2,504	
	Collector		--	--	--	
	Local	37	27,830	1,178	442	
	TOTAL		185,542	7,854	2,946	94.61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total for All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		26,548,174	810,580	308,185	27,666,939

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1977

Time Period Peak-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	31	7,663	394	148	
	Arterial	17	5,860	301	113	
	Collector		-	-	-	
	Local	13	31,553	1,622	608	
	TOTAL		45,076	2,317	869	1.26
2	Freeway	31	6,738	346	130	
	Arterial	17	8,142	418	157	
	Collector		-	-	-	
	Local	13	13,196	678	254	
	TOTAL		28,076	1,442	541	2.07
3	Freeway	31	7,691	395	148	
	Arterial	17	8,905	458	172	
	Collector		-	-	-	
	Local	13	23,882	1,227	460	
	TOTAL		40,478	2,080	780	3.85
4	Freeway		0	0	0	
	Arterial	17	2,694	139	52	
	Collector		-	-	-	
	Local	13	2,295	118	44	
	TOTAL		4,989	257	96	2.89
5	Freeway		0	0	0	
	Arterial	17	5,207	268	100	
	Collector		-	-	-	
	Local	13	7,811	401	151	
	TOTAL		13,018	669	251	5.82
6	Freeway	31	8,414	432	162	
	Arterial	17	6,732	346	130	
	Collector		-	-	-	
	Local	13	26,926	1,384	519	
	TOTAL		42,072	2,162	811	4.23

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway		0	0	0	
	Arterial	17	9, 323	479	180	
	Collector		-	-	-	
	Local	13	10, 100	519	195	
	TOTAL		19, 423	998	375	4. 54
8	Freeway		0	0	0	
	Arterial	17	596	31	12	
	Collector		-	-	-	
	Local	13	3, 661	188	71	
	TOTAL		4, 257	219	83	1. 96
9	Freeway		0	0	0	
	Arterial	17	15, 222	782	293	
	Collector		-	-	-	
	Local	13	8, 563	440	165	
	TOTAL		23, 785	1, 222	458	2. 55
10	Freeway		0	0	0	
	Arterial	18	6, 878	354	133	
	Collector		-	-	-	
	Local	14	8, 074	415	156	
	TOTAL		14, 952	769	289	6. 99
11	Freeway		0	0	0	
	Arterial	18	3, 351	172	65	
	Collector		-	-	-	
	Local	14	4, 265	219	82	
	TOTAL		7, 616	391	147	1. 52
12	Freeway		0	0	0	
	Arterial	18	4, 367	225	84	
	Collector		-	-	-	
	Local	14	3, 873	199	75	
	TOTAL		8, 240	424	159	3. 06
13	Freeway		0	0	0	
	Arterial	18	1, 237	64	24	
	Collector		-	-	-	
	Local	14	5, 635	290	109	
	TOTAL		6, 872	354	133	2. 27

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	31	14, 308	735	276	
	Arterial	18	25, 278	1, 299	487	
	Collector		-	-	-	
	Local	14	8, 108	417	156	
	TOTAL		47, 694	2, 451	919	3. 89
15	Freeway		0	0	0	
	Arterial	18	3, 596	185	69	
	Collector		-	-	-	
	Local	14	5, 394	277	104	
	TOTAL		8, 990	462	173	5. 51
16	Freeway		0	0	0	
	Arterial	18	8, 626	443	166	
	Collector		-	-	-	
	Local	14	10, 126	520	195	
	TOTAL		18, 752	963	361	1. 23
17	Freeway		0	0	0	
	Arterial	18	3, 660	188	71	
	Collector		-	-	-	
	Local	14	6, 798	350	131	
	TOTAL		10, 458	538	202	1. 21
18	Freeway		0	0	0	
	Arterial	18	9, 886	509	191	
	Collector		-	-	-	
	Local	14	7, 159	369	138	
	TOTAL		17, 045	878	329	2. 55
19	Freeway		0	0	0	
	Arterial	18	1, 780	92	34	
	Collector		-	-	-	
	Local	14	1, 780	92	34	
	TOTAL		3, 561	184	68	1. 85
20	Freeway		0	0	0	
	Arterial	18	1, 205	62	23	
	Collector		-	-	-	
	Local	14	4, 817	248	93	
	TOTAL		6, 022	310	116	1. 69

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway		0	0	0	
	Arterial	28	25,513	688	265	
	Collector		-	-	-	
	Local	22	13,738	371	143	
	TOTAL		39,251	1,059	408	7.17
22	Freeway	36	7,697	208	80	
	Arterial	28	59,270	1,599	615	
	Collector		-	-	-	
	Local	22	10,007	270	104	
	TOTAL		76,974	2,077	799	24.78
23	Freeway		0	0	0	
	Arterial	28	17,483	472	181	
	Collector		-	-	-	
	Local	22	4,101	111	43	
	TOTAL		21,584	583	224	3.07
24	Freeway		0	0	0	
	Arterial	28	11,108	300	115	
	Collector		-	-	-	
	Local	22	966	26	10	
	TOTAL		12,074	326	125	3.89
25	Freeway	36	13,692	369	142	
	Arterial	28	17,763	480	184	
	Collector		-	-	-	
	Local	28	5,551	150	58	
	TOTAL		37,006	999	384	9.19
26	Freeway		0	0	0	
	Arterial	28	23,425	632	243	
	Collector		-	-	-	
	Local	28	3,195	86	33	
	TOTAL		26,620	718	276	12.20
27	Freeway		0	0	0	
	Arterial	28	27,401	739	284	
	Collector		-	-	-	
	Local	28	1,442	39	15	
	TOTAL		28,843	778	299	71.50

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	28	3,063	83	32	
	Collector		-	-	-	
	Local	28	5,216	141	54	
	TOTAL		8,279	224	86	15.42
29	Freeway		0	0	0	
	Arterial	28	3,427	92	36	
	Collector		-	-	-	
	Local	28	3,864	104	40	
	TOTAL		7,291	196	76	9.02
30	Freeway		0	0	0	
	Arterial	28	30,962	835	321	
	Collector		-	-	-	
	Local	28	958	26	10	
	TOTAL		31,920	861	331	10.34
31	Freeway		0	0	0	
	Arterial	28	9,983	269	104	
	Collector		-	-	-	
	Local	28	3,507	95	36	
	TOTAL		13,490	364	140	5.15
32	Freeway		0	0	0	
	Arterial	28	52,031	1,403	540	
	Collector		-	-	-	
	Local	28	10,657	287	111	
	TOTAL		62,688	1,690	651	93.15
33	Freeway		0	0	0	
	Arterial	28	10,125	273	105	
	Collector		-	-	-	
	Local	28	1,125	30	12	
	TOTAL		11,250	303	117	6.77
34	Freeway		0	0	0	
	Arterial	28	20,023	540	208	
	Collector		-	-	-	
	Local	28	3,260	88	34	
	TOTAL		23,283	628	242	10.99

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	28	7,138	193	74	
	Collector		-	-	-	
	Local	28	7,429	200	77	
	TOTAL		14,567	393	151	4.79
36	Freeway	36	23,719	640	246	
	Arterial	28	7,441	201	77	
	Collector		-	-	-	
	Local	28	15,347	414	159	
	TOTAL		46,507	1,255	482	12.82
37	Freeway		0	0	0	
	Arterial	28	18,565	501	193	
	Collector		-	-	-	
	Local	28	5,546	150	58	
	TOTAL		24,111	651	251	44.99
38	Freeway		0	0	0	
	Arterial	28	18,577	501	193	
	Collector		-	-	-	
	Local	28	5,240	141	54	
	TOTAL		23,817	642	247	38.72
39	Freeway		0	0	0	
	Arterial	28	36,009	971	374	
	Collector		-	-	-	
	Local	28	5,381	145	56	
	TOTAL		41,390	1,116	430	11.30
40	Freeway	36	4,825	130	50	
	Arterial	28	65,131	1,757	676	
	Collector		-	-	-	
	Local	28	10,453	282	109	
	TOTAL		80,409	2,169	835	22.87
41	Freeway	44	6,627	179	69	
	Arterial	28	12,544	338	130	
	Collector		-	-	-	
	Local	28	4,497	121	47	
	TOTAL		23,668	638	246	19.58

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
42	Freeway		0	0	0	
	Arterial	28	22, 179	598	230	
	Collector		-	-	-	
	Local	28	14, 180	382	147	
	TOTAL		36, 359	980	377	13. 01
43	Freeway	44	2, 732	74	28	
	Arterial	28	19, 122	516	198	
	Collector		-	-	-	
	Local	28	8, 499	229	88	
	TOTAL		30, 353	819	314	50. 62
44	Freeway	44	15, 942	430	165	
	Arterial	28	55, 328	1, 492	574	
	Collector		-	-	-	
	Local	24	22, 506	607	234	
	TOTAL		93, 776	2, 529	973	20. 23
45	Freeway		0	0	0	
	Arterial	28	19, 637	530	204	
	Collector		-	-	-	
	Local	24	3, 465	93	36	
	TOTAL		23, 102	623	240	34. 44
46	Freeway	44	3, 881	105	40	
	Arterial	28	43, 800	1, 181	454	
	Collector		-	-	-	
	Local	24	7, 762	209	81	
	TOTAL		55, 443	1, 495	575	20. 51
47	Freeway	44	5, 187	140	54	
	Arterial	28	36, 780	992	382	
	Collector		-	-	-	
	Local	24	5, 187	140	54	
	TOTAL		47, 154	1, 272	490	58. 34
48	Freeway		0	0	0	
	Arterial	28	17, 716	478	184	
	Collector		-	-	-	
	Local	24	11, 327	306	118	
	TOTAL		29, 043	784	302	8. 28

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	28	8, 369	226	87	
	Collector		-	-	-	
	Local	24	7, 725	208	80	
	TOTAL		16, 094	434	167	11. 38
50	Freeway	44	26, 008	702	270	
	Arterial	28	78, 023	2, 104	809	
	Collector		-	-	-	
	Local	24	58, 517	1, 578	607	
	TOTAL		162, 548	4, 384	1, 686	25. 78
51	Freeway		0	0	0	
	Arterial	28	12, 337	333	128	
	Collector		-	-	-	
	Local	24	13, 365	361	139	
	TOTAL		25, 702	694	267	13. 64
52	Freeway	50	2, 896	47	18	
	Arterial	30	24, 774	405	152	
	Collector		-	-	-	
	Local	30	4, 505	74	28	
	TOTAL		32, 175	526	198	25. 13
53	Freeway	50	5, 296	87	32	
	Arterial	30	71, 496	1, 170	439	
	Collector		-	-	-	
	Local	30	11, 475	188	70	
	TOTAL		88, 267	1, 445	541	189. 39
54	Freeway	50	1, 817	30	11	
	Arterial	30	50, 862	832	312	
	Collector		-	-	-	
	Local	30	7, 871	129	48	
	TOTAL		60, 550	991	371	339. 42
55	Freeway	50	9, 420	154	58	
	Arterial	30	43, 569	713	268	
	Collector		-	-	-	
	Local	30	5, 888	96	36	
	TOTAL		58, 877	963	362	239. 00

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway		0	0	0	
	Arterial	30	22,189	965	377	
	Collector		-	-	-	
	Local	30	2,465	107	42	
	TOTAL		24,654	1,072	419	38.23
57	Freeway		0	0	0	
	Arterial	30	46,706	2,031	793	
	Collector		-	-	-	
	Local	30	4,061	177	69	
	TOTAL		50,767	2,208	862	251.77
58	Freeway		0	0	0	
	Arterial	30	42,908	1,866	728	
	Collector		-	-	-	
	Local	30	3,731	162	63	
	TOTAL		46,639	2,028	791	375.25
59	Freeway	50	33,037	926	343	
	Arterial	30	107,805	3,023	1,120	
	Collector		-	-	-	
	Local	30	33,037	926	343	
	TOTAL		173,879	4,875	1,806	91.09
60	Freeway		0	0	0	
	Arterial	30	15,465	434	161	
	Collector		-	-	-	
	Local	30	3,395	95	35	
	TOTAL		18,860	529	196	20.50
61	Freeway	50	4,872	137	51	
	Arterial	30	17,865	501	186	
	Collector		-	-	-	
	Local	30	4,331	121	45	
	TOTAL		27,068	759	282	17.29
62	Freeway	50	17,828	220	81	
	Arterial	30	87,223	2,446	906	
	Collector		-	-	-	
	Local	30	16,774	470	174	
	TOTAL		111,825	3,136	1,161	233.97

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	50	20,020	561	208	
	Arterial	30	93,427	2,619	970	
	Collector		-	-	-	
	Local	30	20,020	561	208	
	TOTAL		133,467	3,741	1,386	513.30
64	Freeway	50	57,929	1,624	602	
	Arterial	30	35,648	1,000	370	
	Collector		-	-	-	
	Local	30	17,824	500	185	
	TOTAL		111,401	3,124	1,157	173.83
65	Freeway	50	25,983	535	214	
	Arterial	30	70,041	1,441	576	
	Collector		-	-	-	
	Local	30	16,945	349	140	
	TOTAL		112,969	2,325	930	62.34
66	Freeway	50	2,834	58	23	
	Arterial	30	81,233	1,671	669	
	Collector		-	-	-	
	Local	30	10,390	214	86	
	TOTAL		94,457	1,943	778	344.91
67	Freeway	50	25,117	517	207	
	Arterial	30	81,330	1,673	670	
	Collector		-	-	-	
	Local	30	13,156	271	108	
	TOTAL		119,603	2,461	985	431.11
68	Freeway	50	5,704	117	47	
	Arterial	20	21,548	443	177	
	Collector		-	-	-	
	Local	30	4,436	91	37	
	TOTAL		31,688	651	261	24.48
69	Freeway		0	0	0	
	Arterial	30	44,933	1,902	713	
	Collector		-	-	-	
	Local	30	14,977	634	238	
	TOTAL		59,910	2,536	951	53.68

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	50	5,310	225	84	
	Arterial	30	51,587	2,184	819	
	Collector		-	-	-	
	Local	30	18,966	803	301	
	TOTAL		75,863	3,212	1,204	46.99
71	Freeway		0	0	0	
	Arterial	30	52,460	2,221	833	
	Collector		-	-	-	
	Local	30	9,258	392	147	
	TOTAL		61,718	2,613	980	243.21
72	Freeway		0	0	0	
	Arterial	30	17,930	759	285	
	Collector		-	-	-	
	Local	30	3,164	134	50	
	TOTAL		21,094	893	335	94.61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total for All Vehicle Types
	TOTAL		3,061,703	92,805	35,307	3,189,815

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1977

Time Period 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	39	57,470	2,954	1,107	
	Arterial	19	43,949	2,258	847	
	Collector		-	-	-	
	Local	17	236,644	12,161	4,562	
	TOTAL		338,063	17,373	6,516	1.26
2	Freeway	39	50,537	2,597	974	
	Arterial	19	61,066	3,138	1,177	
	Collector		-	-	-	
	Local	17	98,969	5,086	1,907	
	TOTAL		210,572	10,821	4,058	2.07
3	Freeway	39	57,682	2,965	1,112	
	Arterial	19	66,789	3,432	1,287	
	Collector		-	-	-	
	Local	17	179,115	9,206	3,452	
	TOTAL		303,586	15,603	5,851	3.85
4	Freeway		0	0	0	
	Arterial	19	20,208	1,039	390	
	Collector		-	-	-	
	Local	17	17,215	884	332	
	TOTAL		37,423	1,923	722	2.89
5	Freeway		0	0	0	
	Arterial	19	39,053	2,007	752	
	Collector		-	-	-	
	Local	17	58,581	3,011	1,129	
	TOTAL		97,634	5,018	1,881	5.82
6	Freeway	39	63,108	3,243	1,216	
	Arterial	19	50,486	2,594	973	
	Collector		-	-	-	
	Local	17	201,946	10,379	3,893	
	TOTAL		315,540	16,216	6,082	4.23

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway		0	0	0	
	Arterial	19	69,924	3,594	1,348	
	Collector		-	-	-	
	Local	17	75,752	3,893	1,460	
	TOTAL		145,676	7,487	2,808	4.54
8	Freeway		0	0	0	
	Arterial	19	4,469	230	86	
	Collector		-	-	-	
	Local	17	27,455	1,411	530	
	TOTAL		31,924	1,641	616	1.96
9	Freeway		0	0	0	
	Arterial	19	114,165	5,867	2,200	
	Collector		-	-	-	
	Local	17	64,219	3,300	1,238	
	TOTAL		178,384	9,167	3,438	2.55
10	Freeway		0	0	0	
	Arterial	22	51,584	2,651	994	
	Collector		-	-	-	
	Local	18	60,556	3,113	1,167	
	TOTAL		112,140	5,764	2,161	6.99
11	Freeway		0	0	0	
	Arterial	22	25,132	1,292	485	
	Collector		-	-	-	
	Local	18	31,986	1,643	617	
	TOTAL		57,118	2,935	1,102	1.52
12	Freeway		0	0	0	
	Arterial	22	32,751	1,683	632	
	Collector		-	-	-	
	Local	18	29,045	1,493	560	
	TOTAL		61,796	3,176	1,192	3.06
13	Freeway		0	0	0	
	Arterial	22	9,278	476	179	
	Collector		-	-	-	
	Local	18	42,266	2,172	815	
	TOTAL		51,544	2,648	994	2.27

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	39	107, 312	5, 516	2, 068	
	Arterial	22	189, 585	9, 743	3, 654	
	Collector		-	-	-	
	Local	18	60, 809	3, 125	1, 172	
	TOTAL		357, 706	18, 384	6, 894	3. 89
15	Freeway		0	0	0	
	Arterial	22	26, 971	1, 386	520	
	Collector		-	-	-	
	Local	18	40, 457	2, 079	780	
	TOTAL		67, 428	3, 465	1, 300	5. 51
16	Freeway		0	0	0	
	Arterial	22	64, 695	3, 325	1, 247	
	Collector		-	-	-	
	Local	18	75, 945	3, 903	1, 464	
	TOTAL		140, 640	7, 228	2, 711	1. 28
17	Freeway		0	0	0	
	Arterial	22	27, 453	1, 411	529	
	Collector		-	-	-	
	Local	18	50, 986	2, 621	983	
	TOTAL		78, 439	4, 032	1, 512	1. 21
18	Freeway		0	0	0	
	Arterial	22	74, 144	3, 810	1, 429	
	Collector		-	-	-	
	Local	18	53, 691	2, 760	1, 035	
	TOTAL		127, 835	6, 570	2, 464	2. 55
19	Freeway		0	0	0	
	Arterial	22	13, 352	686	257	
	Collector		-	-	-	
	Local	18	13, 353	687	257	
	TOTAL		26, 705	1, 373	514	1. 85
20	Freeway		0	0	0	
	Arterial	22	9, 035	464	173	
	Collector		-	-	-	
	Local	18	36, 130	1, 856	697	
	TOTAL		45, 165	2, 320	870	1. 69

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway		0	0	0	
	Arterial	36	191,345	5,161	1,985	
	Collector		-	-	-	
	Local	28	103,034	2,779	1,069	
	TOTAL		294,379	7,940	3,054	7.17
22	Freeway	45	57,730	1,557	599	
	Arterial	36	444,524	11,990	4,611	
	Collector		-	-	-	
	Local	28	75,050	2,024	779	
	TOTAL		577,304	15,571	5,989	24.78
23	Freeway		0	0	0	
	Arterial	36	131,121	3,537	1,361	
	Collector		-	-	-	
	Local	28	30,758	830	319	
	TOTAL		161,879	4,367	1,680	3.07
24	Freeway		0	0	0	
	Arterial	36	83,307	2,247	864	
	Collector		-	-	-	
	Local	28	7,245	196	75	
	TOTAL		90,552	2,443	939	3.89
25	Freeway	45	102,691	2,770	1,065	
	Arterial	36	133,221	3,593	1,382	
	Collector		-	-	-	
	Local	36	41,631	1,124	431	
	TOTAL		277,543	7,487	2,878	9.19
26	Freeway		0	0	0	
	Arterial	36	175,688	4,739	1,822	
	Collector		-	-	-	
	Local	36	23,958	646	248	
	TOTAL		199,646	5,385	2,070	12.20
27	Freeway		0	0	0	
	Arterial	36	205,507	5,543	2,132	
	Collector		-	-	-	
	Local	36	10,816	292	113	
	TOTAL		216,323	5,835	2,245	71.50

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	36	22, 976	620	239	
	Collector		-	-	-	
	Local	36	39, 122	1, 055	406	
	TOTAL		62, 098	1, 675	645	15. 42
29	Freeway		0	0	0	
	Arterial	36	25, 702	693	266	
	Collector		-	-	-	
	Local	36	28, 982	782	301	
	TOTAL		54, 684	1, 475	567	9. 02
30	Freeway		0	0	0	
	Arterial	36	232, 214	6, 263	2, 408	
	Collector		-	-	-	
	Local	36	7, 182	194	75	
	TOTAL		239, 396	6, 457	2, 483	10. 34
31	Freeway		0	0	0	
	Arterial	36	74, 870	2, 019	776	
	Collector		-	-	-	
	Local	36	26, 306	710	273	
	TOTAL		101, 176	2, 729	1, 049	5. 15
32	Freeway		0	0	0	
	Arterial	36	390, 229	10, 525	4, 049	
	Collector		-	-	-	
	Local	36	79, 927	2, 156	829	
	TOTAL		470, 156	12, 681	4, 878	93. 15
33	Freeway		0	0	0	
	Arterial	36	75, 936	2, 048	788	
	Collector		-	-	-	
	Local	36	8, 438	228	88	
	TOTAL		84, 374	2, 276	876	6. 77
34	Freeway		0	0	0	
	Arterial	36	150, 171	4, 050	1, 558	
	Collector		-	-	-	
	Local	36	24, 446	659	254	
	TOTAL		174, 617	4, 709	1, 812	10. 99

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	36	53,536	1,444	556	
	Collector		-	-	-	
	Local	36	55,721	1,502	578	
	TOTAL		109,257	2,946	1,134	4.79
36	Freeway	45	177,890	4,797	1,846	
	Arterial	36	55,809	1,506	578	
	Collector		-	-	-	
	Local	36	115,104	3,104	1,194	
	TOTAL		348,803	9,407	3,618	12.82
37	Freeway		0	0	0	
	Arterial	36	139,240	3,755	1,445	
	Collector		-	-	-	
	Local	36	41,591	1,122	431	
	TOTAL		180,831	4,877	1,876	44.99
38	Freeway		0	0	0	
	Arterial	36	139,328	3,758	1,445	
	Collector		-	-	-	
	Local	36	39,297	1,060	407	
	TOTAL		178,625	4,818	1,852	38.72
39	Freeway		0	0	0	
	Arterial	36	270,070	7,284	2,801	
	Collector		-	-	-	
	Local	36	40,355	1,088	419	
	TOTAL		310,425	8,372	3,220	11.30
40	Freeway	45	36,185	976	376	
	Arterial	36	488,480	13,175	5,068	
	Collector		-	-	-	
	Local	36	78,398	2,115	814	
	TOTAL		603,063	16,266	6,258	22.87
41	Freeway	54	49,701	1,341	516	
	Arterial	36	94,076	2,537	976	
	Collector		-	-	-	
	Local	36	33,727	909	350	
	TOTAL		177,504	4,787	1,842	19.58

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
42	Freeway		0	0	0	
	Arterial	36	166, 343	4, 487	1, 726	
	Collector		-	-	-	
	Local	36	106, 350	2, 868	1, 103	
	TOTAL		272, 693	7, 355	2, 829	13. 01
43	Freeway	54	20, 489	553	212	
	Arterial	36	43, 417	3, 869	1, 488	
	Collector		-	-	-	
	Local	36	63, 741	1, 719	662	
	TOTAL		227, 647	6, 141	2, 362	50. 62
44	Freeway	54	119, 564	3, 225	1, 241	
	Arterial	36	414, 959	11, 192	4, 304	
	Collector		-	-	-	
	Local	30	168, 797	4, 553	1, 751	
	TOTAL		703, 320	18, 970	7, 296	20. 23
45	Freeway		0	0	0	
	Arterial	36	147, 279	3, 972	1, 527	
	Collector		-	-	-	
	Local	30	25, 991	701	270	
	TOTAL		173, 270	4, 673	1, 797	34. 44
46	Freeway	54	29, 108	785	302	
	Arterial	36	328, 503	8, 860	3, 408	
	Collector		-	-	-	
	Local	30	58, 217	1, 571	605	
	TOTAL		415, 828	11, 216	4, 315	20. 51
47	Freeway	54	38, 900	1, 049	404	
	Arterial	36	275, 843	7, 440	2, 861	
	Collector		-	-	-	
	Local	30	38, 900	1, 049	404	
	TOTAL		353, 643	9, 538	3, 669	58. 34
48	Freeway		0	0	0	
	Arterial	36	132, 873	3, 584	1, 379	
	Collector		-	-	-	
	Local	30	84, 952	2, 291	881	
	TOTAL		217, 825	5, 875	2, 260	8. 28

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	36	62,764	1,693	651	
	Collector		-	-	-	
	Local	30	57,935	1,563	601	
	TOTAL		120,699	3,256	1,252	11.38
50	Freeway	54	195,057	5,261	2,024	
	Arterial	36	585,171	15,782	6,071	
	Collector		-	-	-	
	Local	30	438,879	11,837	4,552	
	TOTAL		1,219,107	32,880	12,647	25.78
51	Freeway		0	0	0	
	Arterial	36	92,529	2,495	960	
	Collector		-	-	-	
	Local	30	100,240	2,704	1,040	
	TOTAL		192,769	5,199	2,000	13.64
52	Freeway	56	21,719	356	134	
	Arterial	38	185,808	3,040	1,140	
	Collector		-	-	-	
	Local	37	33,784	553	207	
	TOTAL		241,311	3,949	1,481	25.13
53	Freeway	56	39,719	650	243	
	Arterial	38	536,219	8,773	3,291	
	Collector		-	-	-	
	Local	37	86,059	1,408	528	
	TOTAL		661,997	10,831	4,062	189.39
54	Freeway	56	13,624	223	84	
	Arterial	38	381,465	6,241	2,340	
	Collector		-	-	-	
	Local	37	59,036	966	362	
	TOTAL		454,125	7,430	2,786	339.42
55	Freeway	56	70,652	1,156	434	
	Arterial	38	326,769	5,346	2,005	
	Collector		-	-	-	
	Local	37	44,159	722	271	
	TOTAL		441,580	7,224	2,710	239.00

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway		0	0	0	
	Arterial	38	166, 417	7, 235	2, 824	
	Collector		-	-	-	
	Local	37	18, 491	804	314	
	TOTAL		184, 908	8, 039	3, 138	38. 23
57	Freeway		0	0	0	
	Arterial	38	350, 294	15, 230	5, 944	
	Collector		-	-	-	
	Local	37	30, 460	1, 325	516	
	TOTAL		380, 754	16, 555	6, 460	251. 77
58	Freeway		0	0	0	
	Arterial	38	321, 807	13, 992	5, 460	
	Collector		-	-	-	
	Local	37	27, 983	1, 217	475	
	TOTAL		349, 790	15, 209	5, 935	375. 25
59	Freeway	56	247, 778	6, 947	2, 573	
	Arterial	38	808, 541	22, 669	8, 396	
	Collector		-	-	-	
	Local	37	247, 779	6, 947	2, 573	
	TOTAL		1,304, 098	36, 563	13, 542	91. 09
60	Freeway		0	0	0	
	Arterial	38	115, 988	3, 252	1, 204	
	Collector		-	-	-	
	Local	37	25, 461	714	265	
	TOTAL		141, 449	3, 966	1, 469	20. 50
61	Freeway	56	36, 542	1, 025	380	
	Arterial	38	133, 988	3, 757	1, 392	
	Collector		-	-	-	
	Local	37	32, 481	911	337	
	TOTAL		203, 011	5, 693	2, 109	17. 29
62	Freeway	56	58, 708	1, 646	610	
	Arterial	38	654, 173	18, 341	6, 794	
	Collector		-	-	-	
	Local	37	125, 804	3, 527	1, 306	
	TOTAL		838, 685	23, 514	8, 710	233. 97

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	56	150, 150	4, 210	1, 559	
	Arterial	38	700, 702	19, 646	7, 276	
	Collector		-	-	-	
	Local	37	150, 150	4, 210	1, 559	
	TOTAL		1,001, 002	28, 066	10, 394	513. 30
64	Freeway	56	434, 465	12, 181	4, 512	
	Arterial	38	267, 362	7, 496	2, 777	
	Collector		-	-	-	
	Local	37	133, 682	3, 748	1, 388	
	TOTAL		835, 509	23, 425	8, 677	173. 83
65	Freeway	56	194, 871	4, 010	1, 604	
	Arterial	38	525, 308	10, 808	4, 323	
	Collector		-	-	-	
	Local	37	127, 091	2, 615	1, 046	
	TOTAL		847, 270	17, 433	6, 973	62. 34
66	Freeway	56	21, 253	437	175	
	Arterial	38	609, 250	12, 536	5, 014	
	Collector		-	-	-	
	Local	37	77, 927	1, 604	641	
	TOTAL		708, 430	14, 577	5, 830	344. 91
67	Freeway	56	188, 374	3, 876	1, 550	
	Arterial	38	609, 973	12, 551	5, 021	
	Collector		-	-	-	
	Local	37	98, 672	2, 030	812	
	TOTAL		897, 019	18, 457	7, 383	431. 11
68	Freeway	56	42, 779	881	352	
	Arterial	38	161, 610	3, 325	1, 330	
	Collector		-	-	-	
	Local	37	33, 272	685	274	
	TOTAL		237, 661	4, 891	1, 956	24. 48
69	Freeway		0	0	0	
	Arterial	38	336, 996	14, 264	5, 350	
	Collector		-	-	-	
	Local	37	112, 331	4, 755	1, 784	
	TOTAL		449, 327	19, 019	7, 134	53. 68

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	56	39, 828	1, 685	632	
	Arterial	38	386, 901	16, 377	6, 142	
	Collector		-	-	-	
	Local	37	142, 243	6, 021	2, 258	
	TOTAL		568, 972	24, 083	9, 032	46. 99
71	Freeway		0	0	0	
	Arterial	38	393, 449	16, 654	6, 245	
	Collector		-	-	-	
	Local	37	69, 433	2, 939	1, 102	
	TOTAL		462, 882	19, 593	7, 347	243. 21
72	Freeway		0	0	0	
	Arterial	38	134, 471	5, 693	2, 135	
	Collector		-	-	-	
	Local	37	23, 729	1, 004	377	
	TOTAL		158, 200	6, 697	2, 512	94. 61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway		TOTAL LD	TOTAL HD	TOTAL DIESEL	VMT Total for All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		22,962,734	695, 964	264, 718	23,923,416

Vehicle Miles of Travel (VMT)

Metropolitan Area Pittsburgh

Year 1977

Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway	39	76,627	3,938	1,476	
	Arterial	19	58,598	3,011	1,129	
	Collector		-	-	-	
	Local	17	315,525	16,215	6,082	
	TOTAL		450,750	23,164	8,687	1.26
2	Freeway	39	67,382	3,463	1,298	
	Arterial	19	81,421	4,184	1,569	
	Collector		-	-	-	
	Local	17	131,958	6,781	2,543	
	TOTAL		280,761	14,428	5,410	2.07
3	Freeway	39	76,909	3,953	1,482	
	Arterial	19	89,052	4,576	1,716	
	Collector		-	-	-	
	Local	17	238,820	12,274	4,603	
	TOTAL		404,781	20,803	7,801	3.85
4	Freeway		0	0	0	
	Arterial	19	26,944	1,385	520	
	Collector		-	-	-	
	Local	17	22,953	1,179	442	
	TOTAL		49,897	2,564	962	2.89
5	Freeway		0	0	0	
	Arterial	19	52,071	2,676	1,003	
	Collector		-	-	-	
	Local	17	78,108	4,014	1,505	
	TOTAL		130,179	6,689	2,508	5.82
6	Freeway	39	84,144	4,324	1,621	
	Arterial	19	67,315	3,459	1,297	
	Collector		-	-	-	
	Local	17	269,261	13,838	5,190	
	TOTAL		420,720	21,621	8,108	4.23

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
7	Freeway		0	0	0	
	Arterial	19	93, 232	4, 792	1, 797	
	Collector		-	-	-	
	Local	17	101, 002	5, 190	1, 947	
	TOTAL		194, 234	9, 982	3, 744	4. 54
8	Freeway		0	0	0	
	Arterial	19	5, 959	307	115	
	Collector		-	-	-	
	Local	17	36, 607	1, 881	706	
	TOTAL		42, 566	2, 188	821	1. 96
9	Freeway		0	0	0	
	Arterial	19	152, 220	7, 823	2, 933	
	Collector		-	-	-	
	Local	17	85, 625	4, 400	1, 650	
	TOTAL		237, 845	12, 223	4, 533	2. 55
10	Freeway		0	0	0	
	Arterial	22	68, 779	3, 535	1, 325	
	Collector		-	-	-	
	Local	18	80, 741	4, 150	1, 556	
	TOTAL		149, 520	7, 685	2, 881	6. 99
11	Freeway		0	0	0	
	Arterial	22	33, 509	1, 722	646	
	Collector		-	-	-	
	Local	18	42, 648	2, 191	822	
	TOTAL		76, 157	3, 913	1, 468	1. 52
12	Freeway		0	0	0	
	Arterial	22	43, 668	2, 244	842	
	Collector		-	-	-	
	Local	18	38, 726	1, 990	746	
	TOTAL		82, 394	4, 234	1, 588	3. 06
13	Freeway		0	0	0	
	Arterial	22	12, 371	635	238	
	Collector		-	-	-	
	Local	18	56, 354	2, 896	1, 087	
	TOTAL		68, 725	3, 531	1, 325	2. 27

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
14	Freeway	39	143,083	7,354	2,757	
	Arterial	22	252,780	12,991	4,872	
	Collector		-	-	-	
	Local	18	81,079	4,167	1,563	
	TOTAL		476,942	24,512	9,192	3.89
15	Freeway		0	0	0	
	Arterial	22	35,961	1,848	693	
	Collector		-	-	-	
	Local	18	53,943	2,772	1,040	
	TOTAL		89,904	4,620	1,733	5.51
16	Freeway		0	0	0	
	Arterial	22	86,260	4,433	1,662	
	Collector		-	-	-	
	Local	18	101,260	5,204	1,952	
	TOTAL		187,520	9,637	3,614	1.28
17	Freeway		0	0	0	
	Arterial	22	36,604	1,881	705	
	Collector		-	-	-	
	Local	18	67,981	3,495	1,310	
	TOTAL		104,585	5,376	2,015	1.21
18	Freeway		0	0	0	
	Arterial	22	98,858	5,080	1,905	
	Collector		-	-	-	
	Local	18	71,588	3,680	1,380	
	TOTAL		170,446	8,760	3,285	2.55
19	Freeway		0	0	0	
	Arterial	22	17,803	915	343	
	Collector		-	-	-	
	Local	18	17,804	916	343	
	TOTAL		35,607	1,831	686	1.85
20	Freeway		0	0	0	
	Arterial	22	12,046	619	231	
	Collector		-	-	-	
	Local	18	48,173	2,475	929	
	TOTAL		60,219	3,094	1,160	1.69

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
21	Freeway		0	0	0	
	Arterial	36	255, 127	6, 881	2, 646	
	Collector		-	-	-	
	Local	28	137, 378	3, 705	1, 425	
	TOTAL		392, 505	10, 586	4, 071	7. 17
22	Freeway	45	76, 973	2, 076	798	
	Arterial	36	592, 698	15, 986	6, 148	
	Collector		-	-	-	
	Local	28	100, 067	2, 699	1, 039	
	TOTAL		769, 738	20, 761	7, 985	24. 78
23	Freeway		0	0	0	
	Arterial	36	174, 828	4, 716	1, 814	
	Collector		-	-	-	
	Local	28	41, 010	1, 106	425	
	TOTAL		215, 838	5, 822	2, 239	3. 07
24	Freeway		0	0	0	
	Arterial	36	111, 076	2, 996	1, 152	
	Collector		-	-	-	
	Local	28	9, 660	261	100	
	TOTAL		120, 736	3, 257	1, 252	3. 89
25	Freeway	45	136, 921	3, 693	1, 420	
	Arterial	36	177, 628	4, 791	1, 843	
	Collector		-	-	-	
	Local	36	55, 508	1, 498	575	
	TOTAL		370, 057	9, 982	3, 838	9. 19
26	Freeway		0	0	0	
	Arterial	36	234, 251	6, 318	2, 430	
	Collector		-	-	-	
	Local	36	31, 944	861	331	
	TOTAL		266, 195	7, 179	2, 761	12. 20
27	Freeway		0	0	0	
	Arterial	36	274, 009	7, 390	2, 843	
	Collector		-	-	-	
	Local	36	14, 421	389	150	
	TOTAL		288, 430	7, 779	2, 993	71. 50

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
28	Freeway		0	0	0	
	Arterial	36	30, 634	826	318	
	Collector		-	-	-	
	Local	36	52, 162	1, 407	541	
	TOTAL		82, 796	2, 233	859	15. 42
29	Freeway		0	0	0	
	Arterial	36	34, 269	924	355	
	Collector		-	-	-	
	Local	36	38, 642	1, 042	401	
	TOTAL		72, 911	1, 966	756	9. 02
30	Freeway		0	0	0	
	Arterial	36	309, 619	8, 351	3, 211	
	Collector		-	-	-	
	Local	36	9, 576	258	100	
	TOTAL		319, 195	8, 609	3, 311	10. 34
31	Freeway		0	0	0	
	Arterial	36	99, 827	2, 692	1, 035	
	Collector		-	-	-	
	Local	36	35, 074	946	364	
	TOTAL		134, 901	3, 638	1, 399	5. 15
32	Freeway		0	0	0	
	Arterial	36	520, 305	14, 033	5, 398	
	Collector		-	-	-	
	Local	36	106, 569	2, 874	1, 105	
	TOTAL		626, 874	16, 907	6, 503	93. 15
33	Freeway		0	0	0	
	Arterial	36	101, 248	2, 730	1, 050	
	Collector		-	-	-	
	Local	36	11, 250	304	117	
	TOTAL		112, 498	3, 034	1, 167	6. 77
34	Freeway		0	0	0	
	Arterial	36	200, 228	5, 400	2, 077	
	Collector		-	-	-	
	Local	36	32, 595	879	338	
	TOTAL		232, 823	6, 279	2, 415	10. 99

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
35	Freeway		0	0	0	
	Arterial	36	71,381	1,925	741	
	Collector		-	-	-	
	Local	36	74,294	2,003	771	
	TOTAL		145,675	3,928	1,512	4.79
36	Freeway	45	237,186	6,396	2,461	
	Arterial	36	74,412	2,008	771	
	Collector		-	-	-	
	Local	36	153,472	4,139	1,592	
	TOTAL		465,070	12,543	4,824	12.82
37	Freeway		0	0	0	
	Arterial	36	185,653	5,007	1,926	
	Collector		-	-	-	
	Local	36	55,455	1,496	575	
	TOTAL		241,108	6,503	2,501	44.99
38	Freeway		0	0	0	
	Arterial	36	185,770	5,010	1,927	
	Collector		-	-	-	
	Local	36	52,396	1,413	543	
	TOTAL		238,166	6,423	2,470	38.72
39	Freeway		0	0	0	
	Arterial	36	360,093	9,712	3,735	
	Collector		-	-	-	
	Local	36	53,807	1,451	558	
	TOTAL		413,900	11,163	4,293	11.30
40	Freeway	45	48,246	1,301	501	
	Arterial	36	651,306	17,566	6,757	
	Collector		-	-	-	
	Local	36	104,531	2,820	1,085	
	TOTAL		804,083	21,687	8,343	22.87
41	Freeway	54	66,268	1,788	688	
	Arterial	36	125,435	3,383	1,301	
	Collector		-	-	-	
	Local	36	44,969	1,212	467	
	TOTAL		236,672	6,383	2,456	19.58

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
42	Freeway		0	0	0	
	Arterial	36	221, 790	5, 982	2, 301	
	Collector		-	-	-	
	Local	36	141, 800	3, 824	1, 471	
	TOTAL		363, 590	9, 806	3, 772	13. 01
43	Freeway	54	27, 318	737	283	
	Arterial	36	191, 222	5, 158	1, 984	
	Collector		-	-	-	
	Local	36	84, 988	2, 292	882	
	TOTAL		303, 528	8, 187	3, 149	50. 62
44	Freeway	54	159, 419	4, 300	1, 654	
	Arterial	36	553, 278	14, 922	5, 739	
	Collector		-	-	-	
	Local	30	225, 062	6, 070	2, 335	
	TOTAL		937, 759	25, 292	9, 728	20. 23
45	Freeway		0	0	0	
	Arterial	36	196, 372	5, 296	2, 036	
	Collector		-	-	-	
	Local	30	34, 654	934	360	
	TOTAL		231, 026	6, 230	2, 396	34. 44
46	Freeway	54	38, 811	1, 046	403	
	Arterial	36	438, 004	11, 813	4, 544	
	Collector		-	-	-	
	Local	30	77, 622	2, 094	806	
	TOTAL		554, 437	14, 953	5, 753	20. 51
47	Freeway	54	51, 867	1, 399	538	
	Arterial	36	367, 791	9, 920	3, 815	
	Collector		-	-	-	
	Local	30	51, 867	1, 399	538	
	TOTAL		471, 525	12, 718	4, 891	58. 34
48	Freeway		0	0	0	
	Arterial	36	177, 164	4, 778	1, 838	
	Collector		-	-	-	
	Local	30	113, 269	3, 055	1, 175	
	TOTAL		290, 433	7, 833	3, 013	8. 28

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
49	Freeway		0	0	0	
	Arterial	36	83,685	2,257	868	
	Collector		-	-	-	
	Local	30	77,247	2,084	801	
	TOTAL		160,932	4,341	1,669	11.38
50	Freeway	54	260,076	7,015	2,698	
	Arterial	36	780,228	21.042	8,094	
	Collector		-	-	-	
	Local	30	585,172	15,783	6,070	
	TOTAL		1,625,476	43,840	16,862	25.78
51	Freeway		0	0	0	
	Arterial	36	123,372	3,327	1,280	
	Collector		-	-	-	
	Local	30	133,653	3,605	1,386	
	TOTAL		257,025	6,932	2,666	13.64
52	Freeway	56	28,958	474	178	
	Arterial	38	247,744	4.053	1,520	
	Collector		-	-	-	
	Local	37	45,045	737	276	
	TOTAL		321,747	5,264	1,974	25.13
53	Freeway	56	52,959	866	324	
	Arterial	38	714,958	11,697	4,388	
	Collector		-	-	-	
	Local	37	114,745	1,877	704	
	TOTAL		882,662	14,440	5,416	189.39
54	Freeway	56	18,165	297	112	
	Arterial	38	508,620	8,321	3,120	
	Collector		-	-	-	
	Local	37	78,714	1,288	483	
	TOTAL		605,499	9,906	3,715	339.42
55	Freeway	56	94,203	1,541	578	
	Arterial	38	435,692	7,128	2,673	
	Collector		-	-	-	
	Local	37	58,878	963	361	
	TOTAL		588,773	9,632	3,612	239.00

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
56	Freeway		0	0	0	
	Arterial	38	221, 889	9, 647	3, 765	
	Collector		-	-	-	
	Local	37	24, 654	1, 072	418	
	TOTAL		246, 543	10, 719	4, 183	38. 23
57	Freeway		0	0	0	
	Arterial	38	467, 059	20, 307	7, 925	
	Collector		-	-	-	
	Local	37	40, 613	1, 766	688	
	TOTAL		507, 672	22, 073	8, 613	251. 77
58	Freeway		0	0	0	
	Arterial	38	429, 076	18, 656	7, 280	
	Collector		-	-	-	
	Local	37	37, 311	1, 623	633	
	TOTAL		466, 387	20, 279	7, 913	375. 25
59	Freeway	56	330, 371	9, 263	3, 431	
	Arterial	38	1,078, 054	30, 225	11, 195	
	Collector		-	-	-	
	Local	37	330, 372	9, 263	3, 430	
	TOTAL		1,738, 797	48, 751	18, 056	91. 09
60	Freeway		0	0	0	
	Arterial	38	154, 651	4, 336	1, 605	
	Collector		-	-	-	
	Local	37	33, 948	952	353	
	TOTAL		188, 599	5, 288	1, 958	20. 50
61	Freeway	56	48, 723	1, 367	506	
	Arterial	38	178, 650	5, 009	1, 856	
	Collector		-	-	-	
	Local	37	43, 308	1, 214	449	
	TOTAL		270, 681	7, 590	2, 811	17. 29
62	Freeway	56	78, 277	2, 195	813	
	Arterial	38	872, 231	24, 455	9, 058	
	Collector		-	-	-	
	Local	37	167, 738	4, 703	1, 741	
	TOTAL		1,118, 246	31, 353	11, 612	233. 97

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
63	Freeway	56	200, 200	5, 613	2, 078	
	Arterial	38	934, 269	26, 194	9, 701	
	Collector		-	-	-	
	Local	37	200, 200	5, 613	2, 078	
	TOTAL		1,334, 669	37, 420	13, 857	513. 30
64	Freeway	56	579, 287	16, 241	6, 016	
	Arterial	38	356, 483	9, 995	3, 702	
	Collector		-	-	-	
	Local	37	178, 242	4, 997	1, 851	
	TOTAL		1,114, 012	31, 233	11, 569	173. 83
65	Freeway	56	259, 828	5, 346	2, 138	
	Arterial	38	700, 410	14, 411	5, 764	
	Collector		-	-	-	
	Local	37	169, 454	3, 486	1, 394	
	TOTAL		1,129, 692	23, 243	9, 296	62. 34
66	Freeway	56	28, 337	583	233	
	Arterial	38	812, 333	16, 714	6, 685	
	Collector		-	-	-	
	Local	37	103, 903	2, 138	855	
	TOTAL		944, 573	19, 435	7, 773	344. 91
67	Freeway	56	251, 165	5, 167	2, 067	
	Arterial	38	813, 297	16, 734	6, 694	
	Collector		-	-	-	
	Local	37	131, 563	2, 707	1, 082	
	TOTAL		1,196, 025	24, 608	9, 843	431. 11
68	Freeway	56	57, 038	1, 174	469	
	Arterial	38	215, 480	4, 433	1, 773	
	Collector		-	-	-	
	Local	37	44, 363	913	365	
	TOTAL		316, 881	6, 520	2, 607	24. 48
69	Freeway		0	0	0	
	Arterial	38	449, 328	19, 019	7, 133	
	Collector		-	-	-	
	Local	37	149, 774	6, 340	2, 378	
	TOTAL		599, 102	25, 359	9, 511	53. 68

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
70	Freeway	56	53, 104	2, 247	842	
	Arterial	38	515, 868	21, 836	8, 189	
	Collector		-	-	-	
	Local	37	189, 657	8, 028	3, 011	
	TOTAL		758, 629	32, 111	12, 042	46. 99
71	Freeway		0	0	0	
	Arterial	38	524, 599	22, 205	8, 327	
	Collector		-	-	-	
	Local	37	92, 577	3, 919	1, 469	
	TOTAL		617, 176	26, 124	9, 796	243. 21
72	Freeway		0	0	0	
	Arterial	38	179, 295	7, 590	2, 847	
	Collector		-	-	-	
	Local	37	31, 638	1, 339	502	
	TOTAL		210, 933	8, 929	3, 349	94. 61
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total for All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		30,616,952	927, 926	352, 924	31,897,802

APPENDIX E

VMT ALGORITHM

APPENDIX E

There were five important inputs. They are: (1) 1967 VMT, (2) 2000 VMT, (3) 1967 population and employment, (4) 1980 population and employment, and (5) 2000 population and employment. All of these inputs were given by SPRPC zones (968). These inputs were then aggregated into 72 districts by AMV.

The first method used to project VMT by district for 1972 and 1977 was based on VMT increases by county (7) from 1967 to 2000. This VMT increase was then apportioned out to all districts in the county based on relative population and employment growths* in each district. That is,

$${}_{i}VMT_{72} = {}_{j}\Delta VMT_{72-67} \; \frac{{}_{i}PE_{72} - {}_{i}PE_{67}}{{}_{j}\Delta PE_{72-67}}$$

where:

${}_{i}VMT_{72}$ = 1972 VMT for district i

${}_{j}\Delta VMT_{72-67}$ = VMT growth for county j between 1967 and 1972

${}_{i}PE_{72} - {}_{i}PE_{67}$ = district i population plus employment growth between 1967 and 1972

${}_{j}\Delta PE_{72-67}$ = county j population plus employment growth between 1967 and 1972

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*The district population and employment growths were first represented by a weighted factor equal to:

Population + 2 (Manufacturing Employment)
+ 2.5 (Non-Manufacturing Employment)
+ 0.1 (Total Employment)

This factor was found unsatisfactory as VMT growth factors due to its greater weighting of population in districts with few manufacturing employees. The population-employment factor for each district finally used was the sum of population and employment. This factor is a measure of the activity of the district.

The individual district's PE_{72} was linearly interpolated between 1967 and 1980. A similar procedure was followed for 1977 VMT estimates.

It was found that those districts which were projected to experience heavy growths in population and employment might be unfairly receiving too large a portion of the county's increase in VMT.

Many districts which had relatively small 1967 PE totals had the greatest increases in PE totals from 1967 to 1972. These districts were therefore allocated a large portion of the county's VMT growth. This would be reasonable if most of the VMT growth for the district was generated by trips ending or beginning in the district.

It appears reasonable to assume that this method would be feasible in areas where population and employment changes are the prime indicators of travel activity in the districts, and where the transportation facilities in each district are similar. In particular, transit usage and the ratio of freeway VMT to total VMT should be similar for all districts in the county. Another formidable obstacle can also occur if a number of districts in an area decrease in population and employment. In this case, the equation cannot be used.

The results of allocating county VMT growth to districts by using the ratio of a district's 1972 population-employment factor to the county's 1972 population-employment factor was found to be inadequate at the district level. The lack of sensitivity for districts with high transportation growth and low population-employment growth was again prevalent. This method did, however, eliminate the problem of decreasing population-employment totals.

APPENDIX F

RESULTS OF RETROFIT METHODOLOGY

TABLE F-1

SOUTHWESTERN PENNSYLVANIA

Weighted Light Duty Annual Travel

Year	Average Miles Driven (D)*	Fraction of Total Vehicles in Use (V)+	V x D	M ‡
1977	3,600	8.0	28,800	2.65
1976	11,900	12.7	151,130	13.91
1975	16,100	12.0	193,200	17.78
1974	13,200	11.8	155,760	14.33
1973	11,400	10.2	116,280	10.70
1972	11,700	11.3	132,210	12.16
1971	10,000	10.6	106,000	9.75
1970	10,300	8.1	83,430	7.68
1969	8,600	6.0	51,600	4.75
1968	10,900	3.9	142,510	3.91
1967	8,000	1.7	13,600	1.25
1966	6,500	1.2	7,800	.72
1965	6,500	.5	3,250	.30
1964	6,500	.2	1,300	.12
		98.2	1,186,870	100.01

* E. P. A. National Averages

+ R. L. Polk, 1971 (see Table 13)

‡ $M = \frac{V \times D}{\sum V \times D}$

TABLE F-2

SOUTHWESTERN PENNSYLVANIA

Gas Powered Light Duty Vehicles

	1977 Average Emission Reduction for the Area		
Pre-Controlled Vehicles	HC	CO	NO_x
Lean Idle Air/Fuel Ratio Adjustment and Vacuum Spark Advance Disconnect	0.60%	0.22%	0.53%
Oxidizing Catalytic Converter and Vacuum Spark Advance Disconnect	1.63%	1.51%	1.15%
Air Bleed to Intake Manifold	0.50%	1.39%	0%
Exhaust Gas Recirculation and Vacuum Spark Advance Disconnect	0.29%	0.74%	1.14%
Controlled Vehicles			
Oxidizing Catlytic Converter and Vacuum Spark Advance Disconnect	32.8%	32.8%	0%
Exhaust Gas Recirculation and Vacuum Spark Advance Disconnect	0%	0%	15.3%

Source: E. P. A.
Table F-1

APPENDIX G

DETAILED RANKINGS OF THE NON-ECONOMIC IMPACT FOR EACH CONTROL STRATEGY

TABLE G-1. RATING OF ALTERNATIVE STRATEGIES SOCIAL CRITERIA

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	5	Generally acceptable
Loading Zone	4	No obvious conflict with goals
Metering	4	Mixed impact
Information Systems		
Source Control		
Retrofit	2	May be regressive
Inspection	2	May be regressive
Fuel Conversion	3	Impact uncertain
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	5	No apparent negative impacts
Increase Transit Use		
Short Term Transit Impv.	5	Conforms to community goals
Transit Fares	5	Conforms to community goals
Tolls	3	Impact mixed
Parking Taxes and Charges	4	Some aspects adopted
Parking Restrictions	4	Some aspects adopted
Vehicle-Free Zone	2	Tends to conflict with goals
Reserved Bus Lanes	4	Beneficial if justified economically
Increase Fuel Tax	4	User cost
Increase Occupancy		
Car Pools	4	No obvious negative impacts
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	3	Indifferent
Fringe Parking	3	Indifferent
Night Goods Deliveries	3	Indifferent
Government Offices	2	Contrary to stated goals
Zoning	2	Contrary to stated goals

* Criteria defined in Table G-2

** Strategy rated previously in this table

TABLE G-2. SOCIAL CRITERIA

Rating	Criteria
5.0	In conformance with expressed or implied community goals. No obvious negative social impact. Similar program implemented without obvious negative social impact.
4.0	Tending to be in conformance with expressed or implied community goals. Minor negative impacts outweighed by positive impacts.
3.0	Indifferent with respect to expressed or implied community goals. Social impact undetermined or apparently evenly mixed. Implemented elsewhere without net negative social impact.
2.0	Tending to be contrary to expressed or implied community goals. Negative social impact slightly in excess of positive social impact.
1.0	Obviously contrary to expressed or implied community goals. Negative social impact outweigh positive social impact. Implemented elsewhere with obvious net negative social impact.

TABLE G-3. RATING OF ALTERNATIVE STRATEGIES
ADMINISTRATIVE CRITERIA

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	4	
Loading Zone	2	
Metering	1	
Information Systems	2	
Source Control		
Retrofit	2	
Inspection	3	
Fuel Conversion	2	
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	5	
Increase Transit Use		
Short Term Transit Impv.	3	
Transit Fares	3	
Tolls	1	
Parking Taxes and Charges	4	
Parking Restrictions	3	
Vehicle-Free Zone	1	
Reserved Bus Lanes	1	
Increase Fuel Tax	5	
Increase Occupancy		
Car Pools	4	
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	4	
Fringe Parking	3	
Night Goods Deliveries	4	
Government Offices	4	
Zoning	3	

* Criteria defined in Table G-4
** Strategy rated previously in this table

TABLE G-4. ADMINISTRATIVE CRITERIA

Rating	Criteria
5.0	Program currently in existence. Similar program currently in existence. No additional agency, manpower or procedures necessary for implementation.
4.0	Similar program implemented elsewhere. No additional agency or manpower required. Minor additional procedures required for implementation.
3.0	Adaptation of programs existing in area or elsewhere. Minor additions to existing agencies. Minor manpower and procedural requirements.
2.0	Similar program not existing in area or elsewhere. Significant additions to existing agency or minor new agency required. Significant manpower and procedural difficulties in implementation of program.
1.0	Similar program not existing in area or elsewhere. Major new agency or administrative jurisdiction required. Major manpower and procedural difficulties in implementation.

TABLE G-5. RATING OF ALTERNATIVE STRATEGIES LEGAL CRITERIA

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	5	Presently performed
Loading Zone	5	Possible under present arrangements
Metering	2	No agency authorized currently
Information Systems	4	Could be added to existing agency
Source Control		
Retrofit	1	Major legislative action
Inspection	1	Major legislative, implementation
Fuel Conversion	1	Major legislative action
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	1	Doubtful as mandatory measure
Increase Transit Use		
Short Term Transit Impv.	5	Also depends on injunction
Transit Fares	2	Subsidy challenge likely
Tolls	1	Various challenges probable
Parking Taxes and Charges	5	Charges presently controlled
Parking Restrictions	4	Attainable with existing agencies
Vehicle-Free Zone	3	Precedents mixed
Reserved Bus Lanes	3	Implementation troublesome
Increase Fuel Tax	3	Can be done at local level
Increase Occupancy		
Car Pools	1	Doubtful as mandatory measure
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	1	Doubtful as mandatory measure
Fringe Parking	5	Requires other action (rates, etc.)
Night Goods Deliveries	2	Questionable as mandatory measure
Government Offices	3	Local action sufficient
Zoning	3	Local action sufficient

* Criteria defined in Table G-6.

** Strategy rated previously in this table

TABLE G-6. LEGAL CRITERIA

Rating	Criteria
5.0	No legislative enactment at any level required. Existing jurisdiction sufficient for enforcement. Legality of measure assured, due to similar measures currently in operation in area or elsewhere.
4.0	Some expansion of existing legislation required. Minor expansion of existing jurisdiction necessary for enforcement. Legality assured due to the establishment of similar measures elsewhere.
3.0	Local legislative enactment necessary. Enforcement requiring additional responsibility by existing jurisdictions. Legality not assured, due to lack of precedents or mixed precedents.
2.0	Regional legislation required. Enforcement requiring new responsibilities by existing jurisdictions. Legality not assured, due to lack of precedents and succesful challenge of precedents.
1.0	Statewide legislation required. New enforcement agencies or major expansion of existing enforcement jurisdictions required. Legality doubtful due to successful challenge of similar measures in area or elsewhere.

TABLE G-7. RATING OF ALTERNATIVE STRATEGIES
TECHNICAL RATING

Strategy	Rating*	Comments
Reduce Emission Rate		
Traffic Flow Improvements		
Upgrade Existing Streets	5	
Loading Zone	5	
Metering	3	
Information Systems	2	
Source Control		
Retrofit	2	
Inspection	3	
Fuel Conversion	2	
Reduce Vehicle Miles of Travel		
Reduce Travel Demand		
Four Day Week	5	
Increase Transit Use		
Short Term Transit Impv.	5	
Transit Fares	5	
Tolls	5	
Parking Taxes and Charges	5	
Parking Restrictions	5	
Vehicle-Free Zone	2	
Reserved Bus Lanes	3	
Increase Fuel Tax	5	
Increase Occupancy		
Car Pools	4	
Tolls	**	
Metering	**	
Vehicle-Free Zones	**	
Parking Taxes and Charges	**	
Shift Travel Patterns		
Staggered Hours	4	
Fringe Parking	4	
Night Goods Deliveries	3	
Government Offices	4	
Zoning	4	

* Criteria defined in Table G-8.

** Strategy rated previously in this table

TABLE G-8. TECHNICAL CRITERIA

Rating	Criteria
5.0	No technical innovation required. Technology existing and in wide use. No further technical development required.
4.0	No significant technical innovation required. Technology existing and in growth stages. Technology somewhat beyond pilot applications. Minor additional development and expansion of existing technology required.
3.0	Technology developed; no major innovation required. Pilot applications existing. Some expansion and development necessary and currently under way. Technology not in wide use.
2.0	Further technical innovation necessary. State of the art projects now at pilot stage. Significant development and expansion required. Technology not in actual use.
1.0	Technical capability not yet developed or in use. Probability of successful development not assured.